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THE FRANKLIN INSTITUTE.

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Nevada, the Silver State, and Government Irrigation in Nevada. The Truckee-Carson Project.*

BY PROF. OSCAR C. S. CARTER.

The Reclamation Service were fair in giving Nevada the first chance at irrigation, and starting promptly in September, 1903, to build a canal thirty-one miles in length to divert water from the Truckee River and convey it to the channel of the Carson River, where finally a storage reservoir will be built. This canal, together with 270 miles of lateral ditches, is completed, and, according to the Reclamation Service, in June, 1905, occurred the final opening of this project, the first to be constructed under authority of the law of June 17, 1902. If ever a State needed irrigation, that State is Nevada. The greater part of the State is as absolute a desert almost as the Sahara, and the rainfall corresponds closely with that region, being from two to ten inches per year. Moreover, what little rain falls does not fall at the time of year when it will do much good, namely, at the time of growing crops. Rain is most needed in the summer season, not the winter, but the rain shows a pronounced maximum during the winter season in that part of the Great Basin region known as

*Read by title.

TACONY BR.

Nevada, and they get twelve times as much rain in January as they do in July at the Winnemucca, which is about the center of the region. In order to conduct agriculture here successfully and raise fair crops at least twenty inches of rain per year are required. It may be a little less will suffice if it falls at particularly favorable times, but when the rainfall is less than twenty inches per year we cannot raise abundant crops without irrigation. Even trees require for successful growth from twenty to twenty-five inches per year. It is very evident that Nevada cannot rise above the mining stage of prosperity without irrigation. Her brief but remarkable history clearly shows this. No State can be prosperous on the mining industry alone, because when the mines give out, the people leave, because it is impossible then to make a living where agriculture cannot be successfully pursued. The past history of Nevada as a State is the history of the Comstock Lode, the present history of the State is the history of Goldfield, Bullfrog and Tonopah. You cannot separate the mining industry from the history of the State. The Comstock mine built cities, erected telegraph lines and helped to build transcontinental lines, but when the mines were practically exhausted the population dwindled down to about 30,000, which was about one-half the former population of the State. The present gold excitement at Goldfield, Bullfrog, and Tonopah has brought about 15,000 new comers to Nevada. Let us hope that this will be a permanent population and not a population of floaters. When the gold mines give out, and that is the history of all gold mines, let us trust that there will not be the exodus from the State that there was in the seventies, but that the thousands of acres made fertile by irrigation will furnish permanent homes to settlers. This is the more to be desired because Nevada is a State and sends two Senators and a Representative to Washington, and yet the population for a time was 30,000, not equal to some of the inland country towns of Pennsylvania. and

EARLY DISCOVERIES. COMSTOCK LODE.

New Jersey. How like a story from the Arabian Nights reads the discovery and history of the Comstock lode which since the discovery, in 1859, has yielded $200,000,000 in silver and gold and made Nevada a State. James Finney, known as "Old Vir-

ginny," was a native of Virginia. He was a roaming prospector and sort of a human divining rod in whom the miners had much faith. While prospecting over the hills north of Gold Cañon, he was attracted by the appearance of a ledge of rock on the slope of Sun Peak. He climbed up the rocks and wrote a notice of his claim on a piece of paper and hid it in a crevice in the rock. His claim was recognized by the miners although he never attempted to develop it. Virginia City was named after him. Two prospectors by the name of McLaughlin and O'Riley were washing dirt on the slope of the hill with poor results. A little stream of water trickled down the slope, but it was not large enough for them to use their rockers. Accordingly they began to dig a water hole on the side of the Sun Peak where they could use their rockers to wash the earth from the heavy gold scales. The earth thrown out was a yellow sand, pieces of quartz and a black mineral they had never seen before. When they washed this yellow sand in the rockers and the mud washed away they found the bottom fairly glittered with scales of gold. Even with their rude appliances they were quickly making a fortune. The great lode had been tapped again. The facts from which this brief narrative is written are found in the monograph of U. S. Geological Survey on Comstock Mining and Miners, to which the reader is referred for a fascinating account in charming English. A loud-mouthed trickster got the credit for this great discovery of the greatest mine of modern times. The true discoverers, Finney, McLaughlin, O'Riley, Orr and the Grosh Brothers, are to fortune and fame unknown. The Comstock lode is famous throughout the world. Henry Comstock was a tall Canadian fur trader and trapper, who finally wandered to Nevada and prospected around Gold Cañon. He took the vacant cabin of the Grosh Brothers, and two Indians worked his claim while he wandered around. On the evening of the day when McLaughlin and O'Riley made their rich discovery, Comstock came riding over the hill. He saw the limits of their claim and the rich find they had made, and running up to the rocker he ran his hand through the dirt and observed the bright spangles of gold. He then informed them that they were working on his property and that he had taken up a ranch of 160 acres, and their claim and rocker were within his boundary. This was an absurd claim to make, as it was a barren peak and there was no grass for grazing.

He had no title to his claim and no record of his ranch. The land was Government land and was open to anyone who would stake his claim and work it. Comstock finally pursuaded these innocent men to give up part of their claim to himself and his friend. He also made claim to the little stream that trickled down the slope where they had their washer, claiming that it flowed from a stream higher up on his claim. He finally obtained from them a grant of 100 feet on the rich lode providing they could enjoy the water equally. Comstock and his new partners finally concluded that they would conceal their rich find, so they filled up the hole and concealed traces of their work. Their

reason for doing this was, the miners were about to have a meeting and formulate laws for their own government, and also laws for the recording, locating and holding of mining claims. Article 4 had twenty sections, and makes interesting reading at this late day. The Recorder was to keep a well-bound book in which a record of all claims, names of parties locating, the number of feet in claim, and where situated were recorded. Section 11 stated, "No Chinaman shall be allowed to hold a claim in this district." The State of California afterward recognized to a certain extent these laws, and declared they might be offered in evidence in all controversies respecting mining claims, and furthermore that they should govern the decision of the action when not in conflict with the Constitution or the laws of the State. It must be understood that these men were removed from civilization and laws governing criminals, and mining laws were necessary. The Vigilance Committee rode one morning through the valley of the Carson and caught a gang of alleged cattle thieves and murderers. Three judges presided over the trial and lynch law justice was administered; one was hung in another locality after trying to get the names of his companions. Another of the party who owned a station house in the valley was led to execution singing the "Last Rose of Summer," and adjusted the rope about his own neck. Others were fined or banished. This is merely a type of rude frontier justice that prevailed in other States than Nevada. After the miners' meeting, Comstock and

GREAT VALUE OF THE ORE.

his partners staked off their claims and additional ones for discovery. While mining they neglected the black mineral ledge in the center of their claim as worthless. One day a ranchman of Truckee River meadows gave a piece of this black mineral to an assayer. The result of his test showed a value of $3000 in silver and $876 in gold per ton. This black material proved to be argentite, or sulphide of silver. The development of the great Comstock Lode dates from this discovery. Comstock was persuaded to make over his claim to a speculator from California, but his companions jeered him so that he determined to get it back. Accordingly a jury of miners made up of Comstock's friends, gravely decided to give it back to him, as they resented any interlopers from California.

Comstock, however, did not keep his claim very long, but sold it to James Walsh. For $10,990 he and other speculators bought up the other claims. Five-sixths of the location, or 1,166 feet, were sold for $70,601, at the rate of about $60 per foot. Thirty-eight tons of ore were sent across the Sierras to San Francisco, which yielded when smelted $112,000. Comstock and his original partners drifted away, their fortunes were soon spent, and they returned to prospecting the hills and ledges for more gold. After interminable litigation the section became unproductive. Miners were no longer plentiful and the hot water in the shafts discouraged them. This was the condition of affairs when four

MACKEY, FAIR, FLOOD AND O'BRIEN.

miners of experience, who were also daring speculators, determined to get possession of the mines and various claims and also get satisfactory titles. These men were Mackey, Fair, Flood, and O'Brien. Mackey and Fair were born in Ireland. Mackey was a ship carpenter, and drifted to California, where he learned practical mining, as did Fair. Flood was the financier of the party. A large and deep shaft was projected by Fair, over $200,000 were spent searching for the bonanza and the treasury was empty. When the shaft was 710 feet deep the ore vein had widened to twelve feet. When 1500 foot level was

reached the richest ore was met with. Drifts were cut into the mass hundreds of feet and passed through rich ore, 1000 tons of which were taken out daily. As the mine became deeper the Director of U. S. Mint and Prof. Robert E. Rogers, in 1875, estimated that the ore in sight was worth $300,000,000. The stock that brought $1 per share in 1870 brought $176 in 1874, and in 1875 brought $700 per share. The drop came later when, as usual, many fortunes were lost. Hot water began to accumulate in the lower shafts in such enormous quantities that the enormous steam pumps could scarcely cope with it. Mr. Adolph Sutro

SUTRO TUNNEL.

was the leading spirit and promoter, who conceived the idea of driving a tunnel in the foot hills of the Virginia Range to the Comstock Lode. This tunnel was to be about 20,489 feet long—nearly four miles. The height of the tunnel was to be ten feet at first and the width was to be thirteen feet. After reaching a point about a quarter of a mile from the mouth the tunnel was to be five feet wide by six high. This was afterward enlarged by an Act of Congress, calling for an area not less than eight by eight feet. It was determined to sink four ventilating and working shafts at intervals of about a mile, so that the work could be carried on at the same time at different shafts, and when the level of the tunnel was reached a number of men could be at work driving the tunnel at the same time. Senator Stewart was president of the company, but their financial difficulties were disheartening. They wanted to raise $3,000,000 by subscription to build the tunnel, and Eastern capitalists were slow to invest. They promised to invest however if he could start the enterprise in the West. He finally succeeded in getting the mining companies to subscribe $600,000, but they annulled their subscription and the New York capitalists promptly did the same. He visited London and the various European capitals, and tried again New York and Washington and finally was successful. While driving the tunnel the rocks became very hot, and when near the Savage mine the rocks in the tunnel had a temperature of 114°, but when the tunnel was completed and drainage channels cut to the different mines, the drainage water reached the temperature of 137°F.

During the year of 1881, over 4,752,605 tons of water drained from the Comstock Lode through the tunnel. It was used for irrigation in the valley and for driving a turbine wheel. Before the tunnel was completed the estimated cost was $3,000,000, but it was built for about $2,000,000. It has been estimated that 600,000,000 feet of timbers have been used in the mines, enough to build a town of 30,000 six-room, two-story frame houses each 40x25 feet. During twenty years 140 miles of mine galleries were opened by holders of claims. Along the line of the Comstock Lode cities were built containing a population of 20,000. The output of the mines up to 1881 was 7,000,000 tons of bullion worth $306,000,000.

MINERS.

During the year 1880 more than 2770 men were employed at the mines. They were Americans, 770; Irish, 816; English, 640; Canadians, 191; Scotch, 83; Germans, 55; Welsh, 34; Italians, 14; only 2 Russians and 1 Slav. Other nationalities were represented, but in small number. These figures are interesting for comparison with the numbers the various nations of Europe send to-day. These miners worked naked in the mines, having only a breech-cloth to cover the hips and thick soled shoes to protect them from the scorching rocks.

HOT WATER.

It was first thought that the high heat was due to chemical combination of the lode rocks and the hot water; for example, the change of the lode feldspar into kaolin, but this was disproved and the cause seems to be due to the fact that the eruptive or lava rocks have not lost their temperature yet. It never impressed the mine owners and miners that some of the hottest water might be utilized to heat the houses of the nearby towns in winter. Perhaps the hot water system was not developed then and doubtless they were too busy making money to think of other matters. The highest temperature of the water noticed up to 1877 was 154° Fahr., but when the Yellow Jacket shaft was finished a stream of water having a temperature of 170° Fahr.

was met with. Tons of ice were lowered in the mine and ice water drank in large quantities, and it is stated that one man would drink three gallons during a shift of eight hours. A miner who breathed for some time air, the temperature of which was 128° Fahr., was carried fainting to the surface, babbling like a child, having lost his memory temporarily. Another miner working on the 2000-foot level refused to go to the cooling station when warned by his companions. They were not surprised to see him drop his pick and fall dead. Three miners while climbing up a winze from the 1900-foot level were asphyxiated by the terrible heat and foul air; a thermometer registered 135° Fahr. where they died. A misstep would plunge them into hot water which would cause the skin to peel off with fatal results. They were exposed to fearful drops of temperature, because after suffering from the intense heat while working stark naked and the perspiration oozing from every pore, they would be whisked to the surface and exposed to the chilling blast of winter. Pneumonia was a common disease among the miners.

WAGES.

All underground laborers were paid at the rate of $4 per day, no matter whether they were shovelers or pick carriers. Modern methods seemed to prevail among the miners, and when one company held out against the wage rate, a committee was appointed to confer, but this committee consisted of 300 men, who marched to the mine and persuaded the foreman to bring up all the miners so they could ascertain if any were receiving less than $4 per day. Some shovelers admitted receiving less, but the foreman could not persuade the committee that they should receive less on account of the kind of work. Their demand was the same rate for all men working underground, no matter what the work.

FATE OF DISCOVERERS.

Fortune never favored and prosperity never followed any of the first discoverers of the Comstock Lode after their first great find. Finney lost what little money he had and made a poor living selling mining claims. He came to an untimely end by fall-

ing from his horse and fracturing his skull. Comstock, the adventurer, bought a wife from a Mormon for a horse, a revolver and sixty dollars. but she ran away at the first opportunity. He then opened supply stores in Carson City, failed and again became a prospector. His early successes and great hardships turned his brain and he wandered from camp to camp and finally committed suicide. O'Riley lost his money and wandered away from Nevada, but returned again and started to tunnel a foot hill of the Sierras, which was mainly rotten granite. He said the spirits told him there was a mountain of silver and gold ahead. He worked there alone by the light of a candle muttering to himself. The mine caved in on him and when he recovered he was sent to a private insane asylum where he died. McLaughlin, who was an honest, industrious man, had poor luck and finally served as cook for a party of miners. He died in a hospital without enough money to pay for his funeral. Ill luck seemed to pursue these men, while the good fortune of Mackey, Flood, O'Brien and Fair, the final owners of the mine, is known at home and abroad. Agriculture, through irrigation, must, after all, be the hope of Nevada. The county in which the Comstock Lode is located had a population of 16,000 in prosperous times when the mines were paying, but in 1900 it had dwindled to 3,600.

TONOPAH AND GOLDFIELD.

We are afraid history will repeat itself in the case of Tonopah, Goldfield and Bullfrog. When the mines cease to pay, the miners and gold seekers will leave and finally the merchants, and these towns will share the fate of Virginia City. Tonopah lies far to the southeast of the Comstock Lode. The Southern Pacific R. R. connects Tonopah and Goldfield, and Bullfrog is seventy miles east of Goldfield. Tonopah is the oldest of these three very new towns and had a population of several thousand. The pack trains and prospectors got their supplies there before wandering across the desert in search of gold. Goldfield, just sprung into existence a year or so ago, has five hotels, two daily papers, several banks and many other banks of another kind. The population is over ten thousand. Bullfrog, the youngest mining camp, now

a town, has a hotel, electric light plant, newspaper and an expensive water system, and by this time several thousand inhabitants.

They have rapid transit across the desert now. The day of the stage coach, pack train and burro (out little long-eared friend that carries everything and has been called the ship of the desert) has not yet passed by any means. They have automobile lines from Tonopah to Goldfield to Bullfrog, and you are whisked across the desert in a couple of hours and pass the slow moving pack train that makes the same journey in three or four days to Goldfield. A new railroad has been completed connecting Salt Lake City and Los Angeles. It runs through the heart of this mining region. It is said that Borax Smith, of California fame, will build a road through Death Valley in California to connect with Bullfrog. This road will begin at Daggett, on the Santa Fe system, and will also cross the Mojave Desert. Death Valley will be shorn of many of its terrors, some of which are fanciful, when this new line is finished through the valley. The last link of still another trans-continental system will pass from Salt Lake across central Nevada and over the Sierras to the Pacific. When all of these roads are completed Nevada will have a better chance than she ever had before. Another difficulty that Nevada had to contend with in the past was the disposition of the public lands, amounting to about 2,000,000 acres. Congress gave Nevada power to select and dispose of this land as the State saw fit. It is said the Legislature put the land up for sale and the stockmen practically got control of it, naturally selecting sites along the rivers and water holes, which water supplies they could more or less control. This was of course a check to settlers who wished to make a living by farming, which could only be carried on by irrigation.

TOPOGRAPHY AND CLIMATE.

Before explaining the "Truckee, Carson Government Irrigation Project," let us look for a moment at the topography and climate of the State, a clear understanding of which is necessary before the planning and final disposition of any irrigation scheme. Nevada lies wholly in the Great Basin Region. This is an area

between the Sierra Nevada Mountains, of California, on the west and the Wasatch Mountains, of Utah, on the east. It also takes in Southern California and Southern Arizona. Although it is called a Great Basin, it is in reality a plateau in Nevada from 4,000 to 6,000 feet above tide, but it is not a flat plateau. It is covered with from forty to fifty parallel ranges of mountains in Nevada, all trending north and south. These ranges have nothing whatever to do with the Rockies. They are supposed to be fault blocks, due to a break in the strata; one end was pushed up, the other dropped. So that many of them have a long gentle slope on one side and a precipice on the other. The reason it is called a basin region is, the Sierras on the west tower high above the entire region and the rivers that are formed by the melting of the snows in the Sierras, flow down the eastern slope into the basin and never reach the ocean. They either evaporate or sink into the desert and are lost to view. Some of them empty into large shallow lakes that are slowly drying up under the influence of the hot dry air. Other streams entirely disappear during the hot summer. The only large river that reaches the ocean is the Colorado, which is not fed by the Sierras but which receives its supply from the rains and melting snows of the Rockies. The little arable land in Nevada along the rivers supports no timber growth except cottonwoods. The eastern slope of the Sierras contain valuable forests of coniferous trees. The Sierras are high enough to receive sufficient rainfall to support timber growth. On the other mountains the timber depends on the altitude. The lower ranges support a growth of cedar, pinion and manzanita, which does not amount to much. The higher ranges have better timber. The scenery of the Great Basin is characteristic desert scenery. Russel compares it to the parched and desert areas of Arabia and to the shores of the Dead Sea.

The traveler from the East misses the green of the upland and meadow, and the resident of Colorado misses the wide open grassy parks of thousands of acres between the high mountains. The rainfall is but from two to ten inches per year, and as remarked before, it comes in winter when the crops don't need it much. The annual rainfall near the canal at Wadsworth is six inches per year; at Reno, on the Truckee River, the rainfall is about eight inches; at Verdi, near the California line, at higher

elevation, 15 inches per year; at Carson, 12 inches; at Virginia City, in the mountains at an elevation of 6242 feet, the rainfall is seventeen inches. The figures on the desert and in the valley where irrigation will be practiced may be accepted at two to ten inches per year and on the mountains higher. As a consequence of this deficient rainfall the air is remarkably dry and the snows seldom lie in the valley more than a day or two. The maximum temperature is from 100° to 111° Fahr. In summer the nights are cool. The winters are dry and pleasant. Like other parts of the arid West, Nevada contains large areas of grazing land notwithstanding the extreme aridity. This grazing land is not equal, however, to parts of the Great Plains east of the Rockies. When the 12th Census was taken an estimate was made of the number of cattle in the different States and Territories. Texas had over 9,000,000 cattle, Kansas over 4,000,000, Nebraska over 3,000,000. Nevada only had at that time 386,249 cattle. Of course the area of grazing land is small compared with other States and the population was and is small. The valleys, though desolate and of little value for agriculture without irrigation, are covered with sage brush, desert shrubs and some bunch grass, all of which form a pasture better in some places than others.

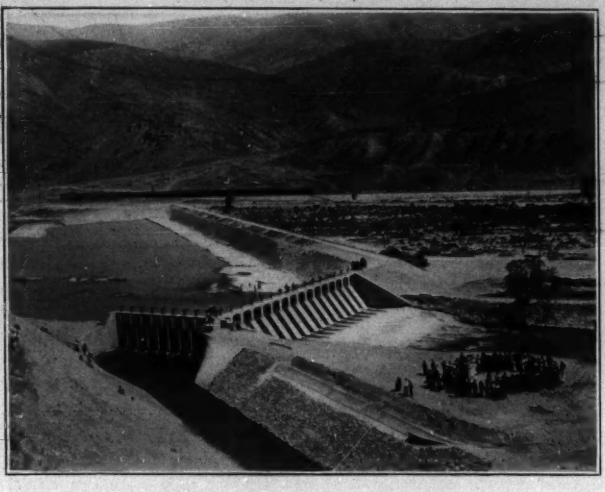
TRUCKEE-CARSON PROJECT.

The water that is to irrigate Nevada comes from the Sierra Nevada Mountains, in the western part of Nevada and the eastern part of California. The rains and the melting snows of the Sierras drain into Lake Tahoe, one of the largest mountain lakes in America, 6225 feet above sea level. The greatest depth of Lake Tahoe is nearly 2,000 feet. The greatest length from north to south is twenty-one and a half miles. The greatest width is twelve miles. The Sierras tower high above the lake. This lake is to furnish the water for the Truckee-Carson project, but unfortunately the boundary line between California and Nevada passes through the lake, so that two-thirds of the lake is in California, therefore Nevada has not sole control of the lake. California cannot well use the lake for irrigation because that part of the State is in the Sierras and is very rocky, but the mountains near the lake once had a heavy growth of timber and the Cali-

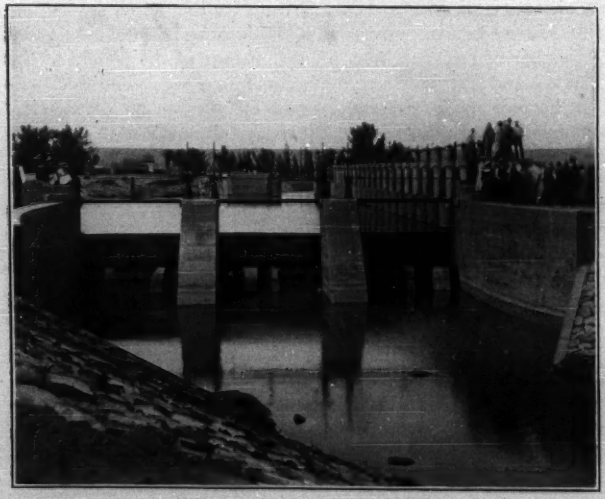
fornians floated the logs down the lake into the Truckee River, where they built a dam and saw mills run by water power. The Truckee River drains this lake, or better, it is the natural outlet for it, and the river after leaving the lake flows northward for a distance of thirty miles or more through California with a winding course. It enters Nevada near Verdi. In the mountains it is fed by a number of small streams. When the river enters Truckee Basin it flows towards the east for a distance of forty-five miles. In this part of its course it passes through Reno Valley and Lower Truckee Cañon to Wardsworth. It then flows about twenty miles northward and empties into Pyramid and Winnemucca Lakes. About thirty miles south of the Truckee River is the Carson River. The project is to build a canal thirty-one miles in length (now completed) from the Cañon of the Truckee near Wardsworth to the Carson River. This canal will take the flood and excess waters of Truckee River that would otherwise be lost in Pyramid Lake and Winnemucca Lake and carry them in a southeasterly direction to a reservoir site on the Carson River. Into this reservoir site will also pour the excess waters of the Carson River. From the reservoir distributing canals can be built to cover, according to the Reclamation Service, several hundred thousand acres of land near Carson Sink. A number of reservoir sites for the storage of the waters of the Truckee and Carson Rivers have been surveyed. The Reclamation Service realize that the simplest plan from an engineering standpoint is to utilize Lake Tahoe, but they say that owing to legal difficulties it has not been deemed wise to begin at the upper end of the river, the reason being that part of the lake is in California. The Reclamation Service in January, 1906, issued the following statement:

NEVADA: TRUCKEE-CARSON PROJECT.

"When completed it is believed that this system will provide an ample supply of water to irrigate about 350,000 acres of arid land in Western Nevada. The first work of actual construction was begun in September, 1903, on a canal thirty-one miles in length to divert water from the Truckee River and convey it to the channel of the Carson River, where a storage reservoir



Opening of Truckee project, June 17, 1905, by Congressional commission.



Congressional party investigating the newly completed head-works on the Carson River, June 17, 1905. Truckee-Carson project.

U. S. Reclamation Service.

Looking west up Truckee canal from top of tunnel 2 in division 2, showing a completed portion of the cement lined canal. Sta. 389+04.

A completed portion of cement lined canal just below the east end of tunnel 1 in division 2, Truckee-Carson project, Nev.

eventually will be built. This canal, together with about 270 miles of lateral ditches, is completed, and on June 17th, 1905, the third anniversary of the Reclamation Act, occurred the formal opening of this project, the first to be constructed under authority of the law of June 17th, 1902. Water is now ready for delivery to about 50,000 acres, 30,000 of which are public lands, which have been thrown open to homestead entry, and may be filed upon by bona fide settlers, in accordance with the rules and regulations of the homestead laws and Reclamation Act. The lands are tributary to the Southern Pacific and the Nevada and California Railroads. An assessment of $26 per acre will be charged against the land for its water right, payable in ten annual installments without interest. Maps showing the location of available entries may be inspected at Carson City, Nevada, land office, where application should be filed. The construction of outlet and regulation works at the outlet of Lake Tahoe and the extension of the system to include additional areas will be undertaken at an early date."

Although the final plan is to reclaim 350,000 acres of land, the immediate plan is to reclaim 200,000 acres in Carson Sink Valley, north of Carson Lake. The small town of Fallon is about in the center of the area to be irrigated. The following description of the main features of the irrigation system is taken from the fifth annual report of the Reclamation Service:

"(1) A main diversion canal for carrying the waters of the Truckee River over the low divide to the Carson Basin and thence around the west side of the valley to Carson River at the dam site for the Lower Carson Reservoir; (2) main distributing canals for diverting water from Carson River below the reservoir to the principal bodies of land in Carson Sink Valley; (3) the lateral distributing system for the further distribution of water to the lands to be reclaimed; (4) the conversion of Lake Tahoe into a reservoir with a capacity of 200,000 acre-feet for holding part of the water; (5) a reservoir with an approximate capacity of 220,000 acre-feet in the Alkali Flat site north of Carson River for storing surplus water from Carson River; (6) the building of the Lower Carson Reservoir by which 286,500 acre-feet of the combined waters of the Truckee and the Carson may be stored.

"The Truckee Canal is designed to carry about 1200 second-

feet of water from the Lower Truckee Cañon into the Lower Carson Reservoir and about 200 second-feet to a point in the cañon convenient for a branch to the Pyramid Lake region.

DIVISIONS OF CANAL.

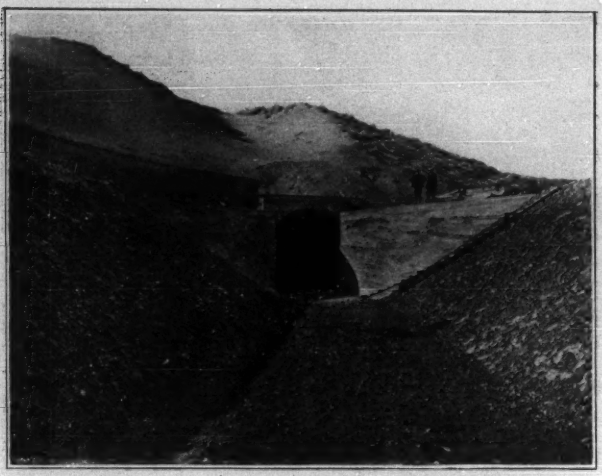
"The canal is 30.9 miles long and is divided into three divisions. Division 1 extends from the head to the 6-mile point; division 2 extends from the 6-mile point to the 13-mile point, and division 3 extends from the 13-mile point to the end. An important part of division 1 is the diversion dam and headworks. There are several expensive concrete structures on divisions 1 and 2, and on division 2 are three tunnels. Division 3 is entirely in open country. All structures are of Portland cement concrete and iron or steel, no wood being used except for minor parts such as flashboards.

DIVERSION WORKS.

"The headworks consist essentially of a diversion dam across the river and of headgates at the entrance of the canal. The diversion point is in the cañon about four miles east of Clarks and five miles above Derby, both of which are stations on the Southern Pacific Railroad. It is about ten miles westerly from Wadsworth, which is on the Truckee River. The elevation above sea level at the region of the dam is about 4200 feet. The dam and headgates are built as one structure of concrete, reinforced in places. The dam runs squarely across the river, while the headgate is placed at right angles to the dam, extending up stream from the south end.

DAM.

"The dam is designed for the passage of water through it similarly to a headgate. It is 155 feet long between abutments. From the main foundation arise fifteen piers to serve as posts for the regulating gates, sixteen in number. The foundation is 8.83 feet thick, and thirty feet wide, up and down stream, by 171 feet long over all. It rests on the natural bed of



East portal of tunnel 3, division 2, Truckee canal. Truckee-Carson project, Nev.

Steam dredge in operation, loading cars on banks of Truckee canal. Truckee-Carson project, Nev.

(*Carter*)

U. S. Reclamation Service.

Looking down the Truckee canal through one of the rock cuts at Sta. 45 in division 1.

View looking southeast down the valley, showing a long stretch of Truckee canal under construction. Truckee Carson project, Nev.

light gravel and bowlders. No effort was made to reach solid rock, as it was not necessary. The excavation was carried to an average depth of about five feet below the bed of the river, which is about 145 feet wide. The main piers are fifteen feet high, the top being at high water mark. On the top of each is a smaller pier for the support of the gear for lifting the gates. The smaller pier is 5.25 feet long, 2.5 feet wide and 7.33 feet high. Two lines (157 feet each) of 7-inch beams, 15.3 pounds weight, spaced seven inches between webs, run through the coping of the piers and extend along the line of the gate shafts. These beams support the lifting gears and serve to reinforce the concrete arches that extend from pier to pier. There are sixteen gate openings, each five feet in the clear, between the river piers. Each gate is composed of three sections: (1) The lower gate, used alone for the ordinary regulation of water; (2) the upper gate, called into action only when a large amount of water is required to pass; (3) the flashboards, which may be removed for the passage of extreme high water. The lower gates are of cast iron, the body being 1¼ inches thick and strengthened by radial ribs at 45° intervals. They are five feet seven inches wide by five feet high. The upper gates are cast iron, the body being one inch thick and reinforced by shallow outside and cross ribs. The gates proper are five feet nine and one-quarter inches wide by five feet three inches high. The maximum discharge of the river is probably 10,000 to 12,000 second-feet.

HEADGATES.

"The row of headgates extends up stream from the south end of the dam at an angle of 90°. The supporting structure is an extension of the south abutment of the dam. There are nine gates spaced seven feet between centers and each having a clear opening of five feet. The distance between the end walls is sixty-one feet. The framework of the structure supporting the gates is of steel and consists of eight posts and one main girder. The main girder is at the top above the gates and spans the space between the end walls. Each gate has only two flashboards of only eight-inch width. The sill of each gate is a four by four-inch timber set flush in the main concrete sill. This sill is two feet and three

feet eight inches above the bed of the canal and the floor of the dam. This is to favor the sluicing through the dam of sand and silt that accumulates in front of it. The bed of concrete here is about six feet deep. On the side next the river a curtain wall or cut-off wall of average thickness of fifteen inches is carried down to the same level as the bottom of the foundation of the dam.

TRUCKEE CANAL IN TRUCKEE CANON.

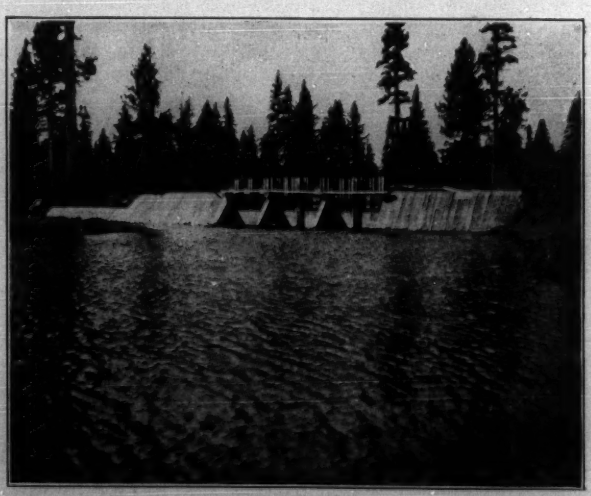
"The portion of the Truckee canal in the cañon represents the most difficult work and the greater part of the expenditure. It includes all of division 1 (six miles) and four miles of division 2. The sides of the cañon slope for the most part at angles ranging from 5° to 30°. The formation is heterogeneous, consisting of earth, gravel, talus, cemented material of various kinds and several kinds of rock. There is considerable calcareous tufa and some very coarse sandstone. The only real hard rock found is a kind of trap rock. The formation is so much broken or open and porous that it is not well adapted for holding water. The only clayey matter present is a fine silt, a characteristic deposit in the old lake beds of all this region. It is the only natural substance available for puddling or for silting up the sides and bottoms of canals.

CONCRETE LINING.

"Concrete lining is used under a variety of circumstances. (1) In rock excavations it is employed to make a smoother section and thus allow a narrower cross section and consequent reduction in yardage. (2) It is used in light porous materials and in very broken seamy or fissured rock in order to prevent leakage; and (3) it is employed in places where leakage or washouts might have serious consequences. The standard thickness of lining used was generally about six inches, but in one place four inches was adopted. It was possible to use four inches where the rock was not too much shattered or too rough. All lining is brought up to an elevation two feet above water line, at the grade for top of banks. The amount of concrete per linear foot of canal varied all the way from 0.6 cubic yard to 1.4 cubic yards,

U. S. Reclamation Service.

Lower Carson reservoir site, looking southwest from the dam site.



A dam in Truckee River at Lake Tahoe.

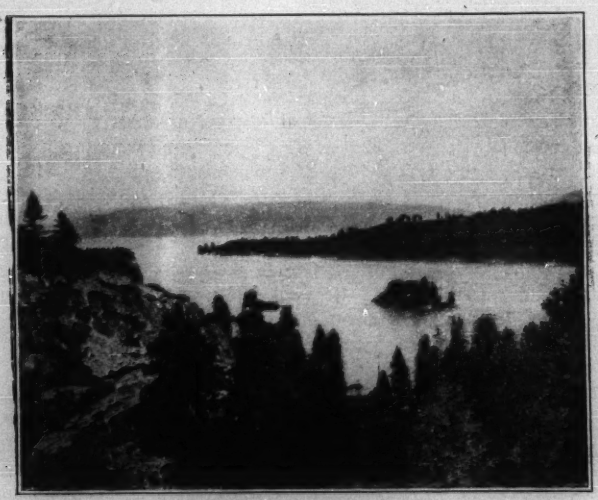
depending on width and slopes and on the thickness of lining. On the section with twenty feet width and one-half to one slopes, a thickness of six inches requires one cubic yard. The total cost to the Government of all items for the concrete was about $9 per cubic yard.

TUNNELS.

"There are four tunnels on the Truckee Canal, all on division 2. As the material to be encountered was known to be variable, three methods of lining tunnels were prescribed in the specifications: (1) Temporary timbering was put in during excavation and the permanent lining of concrete was put in afterwards, the timbers remaining in the concrete. (2) No timbering was put in or the timbers were moved when the tunnels were lined with concrete. (3) In hard rock the tunnels were plastered with a coat of cement plaster. The finished section of concrete by either methods one or two is twelve feet wide, twelve feet high to the springing line and has a three centered arch 3.35 feet high. The water section is thirteen feet deep. Tunnel No. 1 is about 6½ miles from the head of the canal. It is 901 feet long between portals. Under natural conditions this tunnel would not have been built, though it saves much side hill work and some distance, but the location of the railway required it. The material encountered is a dark, hard flinty rock with many seams and slips. The greatest height to the surface of the ground over the tunnel is probably as much as 200 feet. Tunnel No. 2 is about 7.4 miles from the head of the canal. It is 308.7 feet long all on tangent and the portal cut has a length of about seventy-five feet. The topography here determined its use, aside from the obstruction offered by the railway to an open canal. This tunnel was constructed without timbering. The material encountered was a red rock not hard but compact, tough and without seams, so that it broke up short in blasting and could be cut close to line. The greatest elevation of the surface over the tunnel grade is only 58 feet. Tunnel No. 3 begins 8.5 miles from the head of the canal. It is 1,515 feet long. The portal cuts are about thirty-five and forty feet long at the upper and lower ends. The greatest vertical distance from the tunnel grade to the surface was just 100 feet. The material driven through was earth all

the way and no powder was used. For about 150 feet of the exit end (east end) there was a loose sand without admixture of adhesive materials, which ran very freely, and the difficulties were so great that the progress with two shifts was less than one foot per day. Tunnel No. 4 is located 7.6 miles from the head of the canal. It is required to pass the water of a wasteway at this point under the railway track to discharge into the river.

U. S. Reclamation Service.



View looking east from head of Emerald Bay, Lake Tahoe.

The water drops down to the head of this tunnel from the wasteway through a shaft forty-nine feet deep.

TRUCKEE CANAL BELOW TRUCKEE CANON.

"At a point about ten miles from the head works the canal reaches the end of the Truckee Cañon and comes into a wide valley. Here the work was much simpler and easier and no structures were required. The canal lies on the gentle slope

which has tapered out from the foothills. The canal discharges into Carson River, near the dam site for the Lower Carson Reservoir, at a point 30.9 miles from the head. This terminal point is a little west of south of Hazen, and seven miles distant.

DISTRIBUTING CANALS.

"The main distributing canals form the second essential part of the Truckee Carson project. Their office is to divert the waters from the Carson River to the main bodies of land to be irrigated. At present the principal body of land is that south of Carson River in the neighborhood of Fallon. The diversion for both sides of the river is made at a point about four miles above (west of) Leetville post office and five miles below the dam site for the Lower Carson Reservoir. The canal on the south side of the river was designed to have a capacity of 1500 second-feet and that on the north side of 450 second-feet. The lateral system is for the subdivision and conveyance of the water in the main distributing canals to the land to be irrigated, including in most cases the delivery at the higher side of each farm unit. The irrigable lands in the Carson Sink Valley have been divided into seven divisions or districts, each containing 20,000 to 50,000 acres. Each district will have a system of lateral distributaries and necessary waste ditches or drains.

PYRAMID BRANCH CANAL.

"Six miles from the head of the canal, at the end of division 1, there is provided a take-off for the canal which is to serve the Pyramid Lake area. This consists essentially of: (1) A set of head-gates (more properly check-gates) in the main canal for use in holding back the water when required to give a good head for turning it into the branch canal; (2) the head-gate of the branch canal itself; (3) the supporting structures, approach section of canal, etc."

FRUITS AND VEGETABLES.

The same fruits that grow in Pennsylvania can be successfully cultivated on these Truckee farms, apples, peaches, pears, plums

and cherries, also the smaller fruits, as strawberries, raspberries, gooseberries and blackberries. All the cereals can be grown in abundance, particularly wheat. Corn is a profitable crop also. Alfalfa it yields five tons to the acre. All the common vegetables find a ready market in the mining camps or can be shipped to San Francisco, as can the fruits. This land will not fall into the hands of speculators or corporations, because a man to own eighty acres must live on it and he must visit it first and inspect it before he files his application. He cannot file an application if he owns 160 acres elsewhere. Foreigners who have not declared their intention of becoming citizens cannot secure land, neither can minors or married women, except where the husband is disabled. When persons secure Government land they are expected to live on it and cultivate it.

VERIFICATION OF ARTESIAN WATER PREDICTIONS IN CENTRAL SOUTH DAKOTA.

The great practical value of the underground water investigation of the United States Geological Survey has recently received another demonstration—this time in central South Dakota. In this region the western extension of the Northwestern Railroad system from Pierre to Rapid City has built up the valley of Bad River, and the company has sunk three wells to supply water for locomotives and other uses. In sinking the wells the company was guided entirely by a map published in a report on the geology and underground water resources of the central Great Plains, of which South Dakota forms a part, published by the Survey as Professional Paper, No. 32. This map, prepared by Mr. N. H. Darton, the author of the report, indicated in a general way the areas in which artesian flows might be found and showed the probable depths at which the great water-bearing formation of the Great Plains, known to geologists as the Dakota sandstone, would be reached. The predictions made by Mr. Darton on this map were very closely verified by the railroad company's wells. At Capa, where the top of the Dakota sandstone was shown by the map to be at a depth of about 1510 feet, it was found at 1500 feet. At Nowlin farther up the valley, the depth predicted was between 1500 and 2000 feet, or approximately 1750 feet, and the water-bearing Dakota sandstone was entered at 1760 feet. At Wendte, twenty miles west of Pierre, a similar verification of prediction was made.

This is but one instance of many that might be cited in which the water investigations of the Survey have resulted in the successful location of artesian wells.

At Panama.*

By Fullerton L. Waldo, F.R.G.S.

Lieut.-Col. George W. Goethals, U. S. A., Chief Engineer of the Isthmian Canal Commission, reported on December 4 to the Washington office of the Commission that the total excavation for November was 1,838,486 cubic yards, making a daily average for 24 working days of 76,600 cubic yards. Five cubic yards of earth and rock, such as the great ninety-five-ton Bucyrus shovels grub up at a single bite, after the side of a hill has been "shot" or blasted, weigh from seven to nine tons, so that it is safe to say that a daily average of something like 120,000 tons is being hauled seaward on the rocking Western dump cars or being plowed off by the Lidgerwood unloaders from the dirt-trains into the abysmal reek of primeval morasses and the jungle. The French, at their best, were taking out something like 1,500,000 cubic yards a month, twenty years ago. So that in actual cubic yardage we are exceeding the achievement of our predecessors, and the prophecy, which a year ago seemed over-sanguine, that the canal would be ready for commemorative expositions at Los Angeles and New Orleans in 1915, bids fair to be fulfilled.

One of the most interesting books that has ever been written on the Panama Canal is the Report, just issued, of the Canal Commission for the year ending June 30, 1907. The pictures bring the graphic exposition of the conditions much more nearly down to the present date (some bearing the legend September 10, 1907), and make plain the connection between paving and self-respect in the cities; between the adequate housing of the work-

*A lecture delivered before the Franklin Institute, Friday, November 29th, 1907.

ing-corps and a degree of contentment hitherto supposed to be unrealizable on the part of Northerners living in the tropics; between an adequate supply of filtered water and mortality-rates that would be the pride of a New York or Philadelphia Board of Health. No before-and-after-taking advertisement could exhibit more sudden or surprising metamorphoses than this Annual Report represents, and the result of its perusal must be to establish unshakeably the confidence of the reader in the work and in the men who are doing the work. If other evidence were needed that the dirt is flying and that the filth has flown,—that the Isthmus is livable for white men,—that while the great dam at Gatun slowly but surely rises against the chocolate torrent of the Chagres, and the giant cleft in the hills at Culebra grows steadily wider and deeper, the children are going to school and women are marketing much as they do at home—if one wants additional evidence that the American community has transferred American institutions to the Isthmus little altered, one has only to read every week the pages of the *Canal Record*. There he will find the unbiased chronicle of the life of the thirty thousand people of the working community. He will learn there how the surveyors in the Chagres Valley have come upon a little French village under the *bejucca* vines and the white orchils, with machine shops whose clinking and purring tools have given place to the strident voices of the paroquets and the jabber of monkeys. He will learn there of judges and lawyers soberly holding court for undesirable citizens and meting out even-handed American justice. He will find contract vs. day labor discussed, and the scores of a woman's bridge-whist club duly held up for emulation. He will learn of Japanese teas and Spanish classes, baseball and bowling alleys, and Thanksgiving pumpkin pie. There are "letters from the line," about how small boys scraped the frost from the pipes of the cold-storage plant and snow-balled each other,—about a challenge to a walking match across the Isthmus, or the Continent, if you like, some 44 miles of distance,—about the establishment of fraternal orders, with much band music and lemonade. There is one wistful column of the names of those who are going back to God's own country by the constant shuttle of the steamships,—a wistfulness tempered by the welcome extended to those who are coming back to the Isthmus again, after the long vacations granted every employee.

It is good to read about all this, but it is still better to have been down there and to have seen for one's self how things are going, as it is the writer's privilege to have been and to have seen, last winter.

Those who have seen Dwight Elmendorf's lectures with their accessories of motion and color, need in addition little more than six months of dry heat followed by six months of supersaturation, to realize what life at Panama is like. The abominable climate that makes garden vegetables as difficult to raise as little children—that often pulls down the white man's capacity for "virtuous energizing" to the low level of the black man's vegetative existence—that brings green mold on books and ants into the woodwork, and makes taut fiddle-strings impossible—even this climate, if you live as Dr. Gorgas lives, who follows the rules and obeys the laws of tropic nature,—becomes tolerable. That is the first thing, of course, that the new-comer broods about—he is obsessed by fear that the climate will sap and undermine his energy and leave him a prey to Chagres fever or elephantiasis. How do the statistics of Dr. Gorgas' latest health report justify the apprehension? "The sick rate for September," Dr. Gorgas reports, "was 27.78 per thousand, and for August 29.02—a decrease of nearly 2 for September as compared with August. The same rate for September, 1906, was 37 per thousand.

"The number of employees on our rolls on the 1st of September was the largest that has so far appeared on the rolls of the Commission—slightly over 41,000. In September, 1906, we had something over 28,000 employees. Among these 28,000 employees we had 135 deaths, which gave us an annual death rate of a little over 57. In September, 1907, we had 41,000 employees, with 98 deaths, giving us an annual death rate of a little over 28 per thousand—quite a marked improvement.

"Among our 4,200 American employees we had two deaths, giving us an annual death rate of 5.71—about the same as last year.

"In September, 1906, the total population of the zone was 76,000, from which population we had 350 deaths, giving us an annual death rate of a little over 54 per thousand. In September, 1907, the zone population was 108,000, in which population we had 297 deaths, giving us an annual rate of a little over 32 per

thousand, showing a very marked improvement in the death rate, both of the laboring force and the general population.

"No case of either small-pox or yellow fever occurred on the zone during the month."

So much for the health of the zone—that ten-mile wide strip which includes the axial line of the Canal and is deflected at either end to skip the cities of Colon and Panama, but not the American suburbs of these cities,—Cristobal and Ancon. Cristobal is a delightful place,—like Manhattan Beach, it is swept by ocean breezes, when there are any; it has an ice plant and cold storage and a steam laundry and a bakery of its own, and the cellarless houses reared on posts, and covered from top to bottom with wire gauze against *anopheles* and *stegomyia*—these houses, cleanly and airy, shed the tropic rains from their corrugated roofs, and the porous soil beneath soaks up the flooding waters, and there are no pockets for standing drainage where mosquito larvæ breed. A shell road in front, and the indolent windmill-arms of the cocoanut palms overhead, and the open roadstead of mud-brown shallow water, with the red and rusted tramp steamers lying at anchor off the railway pier—this is the 'long-shore picture; and just behind you, beside the railway track, are the freight yards, and giant scare-crows of the coal unloaders, and the Mount Hope storehouses, partially destroyed by fire the first of last April. And there is the "Monkey Hill Cemetery," with red zinnias abloom, newly-christened Mount Hope, so that people will forget the horrid stories of the French regime, and how the crew of the daily dead-train dumped the corpses out of the coffins upon the hillside, and sold the coffins again. And beyond that still, is the mighty Reservoir, which Poultney Bigelow could not find, and where the launch named for him is tethered to the bank. The water-works system of Colon, which this Mount Hope Reservoir supplies, is now complete. About five miles of sewer pipe were laid in the year covered by the Annual Report. Seventy-five house connections have been made with the water pipe, 414 service boxes and 122 meters installed. The Mount Hope Reservoir, which was completed in December, 1906, has a capacity of 435,000,000 gallons. In watering and paving the cities of Colon and Panama the United States has thus far expended $1,750,000, which is to be reimbursed by the two municipalities from water-rates collected. In the city of Panama last year some two and a-

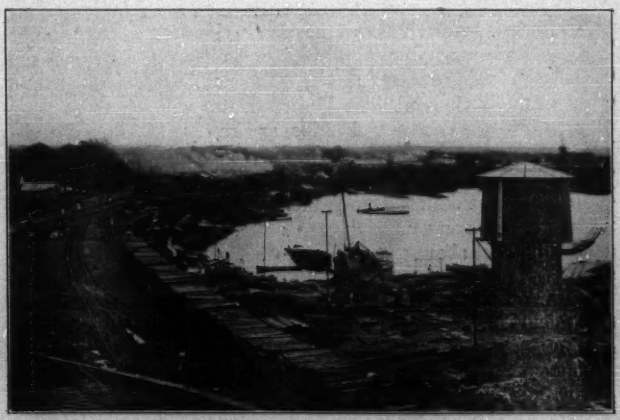
half miles of water pipes were laid, 2,093 houses were connected therewith, two million vitrified brick from Dubuque, Iowa, were laid in the streets, and now Panama claims the proud distinction of being the best-paved city between Buenos Ayres and the City of Mexico, with twenty gallons of water per day supplied for each of its inhabitants—many of whom have little or no use for it.

At Colon, where much of the land is only a matter of a few inches above the water, and the soil is a seeping, porous sponge, dredges in the channel are doing most of the work. The dredging fleet comprises one of the old French ladder dredges, a five-yard dipper dredge, and a sixteen-inch suction dredge; more recently, a sea-going suction dredge, like the big dredges in New York Harbor, has been doing yeoman service, adding between three and four hundred thousand cubic yards a month to the sum total. Before this recent acquisition, the excavation for the fiscal year at Colon was eleven hundred thousand cubic yards.

At Gatun, where the railway line must be relocated to swing clear of the vast mass of the dam, is one of the two great present centers of activity, the other being the heart of the Culebra cut. As everybody knows, this dam at Gatun is what the schoolboy would call "the biggest ever." It is not really a dam; it is a hill or mole, or barrow of earth, such as the Ohio mound-builders would have clapped their hands to behold. For a mile and a-half in width it is to reach across the valley, clamping it from hill to hill, and its base a half-mile through, will obliterate the site of the ramshackle, palm-thatched, native village of Gatun, with its little gray Catholic church. The United States will lift those poor little sentry-box houses to the hills, or else rebuild before the village moving-day. And by that great earth-barrow, whose dimensions are only approached, but not equalled, by a couple of earth-dams in California, an immense lake will be created, as the whole world knows, with the top of the dam, a hundred yards wide, fifty feet above the surface of the water at the eighty-five-foot level.

The three locks at Gatun are in pairs; the present dimensions are 1000x100 feet, and there is much talk of widening. On the other side of the Isthmus this lock-flight is counterbalanced by the lift at Pedro Miguel and the two locks at La Boca. The design is simple enough, and the engineering problem at Panama presents quantitative rather than qualitative difficulties. There

Flood of December 8, 1907, on the line of the Panama R. R. at Paraiso.



Freight yards at Mount Hope, just outside Colon.

Native village at Gatun. The village will be razed and its site obliterated by the dam.

The rock cutting at Bas Obispo, the beginning of the Culebra cut.

never has been any reasonable doubt about those famous lock foundations at Gatun. Flurried conjecture in Congress was set at rest, May 2, 1907, by Messrs. Noble, Stearns and Freeman, when they reported: "We beg to record that we found that all of the locks of the dimensions now proposed will rest upon rock of such a character that should furnish a safe and stable foundation." I saw myself, when I was there last winter, the blue-prints of some five hundred borings taken all over the lock site and the dam site to determine beyond peradventure that the dam and the accessory works are not going to shift uneasily upon their bed so as to undo the work of years and render vain the expenditure of millions.

Mr. Ernest Howe, the geologist, makes some interesting and instructive remarks in the Annual Report, anent the nature of the clay beds at Gatun. He says: "The rocks are all well consolidated, though in a few rare cases sandy layers are found which crumble on exposure to the air. These are the beds that have been referred to frequently as 'indurated clays.' The term is a misleading one, since true clays make up but a small part of the formation. Induration is a term applied to the process by which sandstones or argillaceous rocks are converted into quartzites or slates by heat or mineralized solutions accompanying the intrusion of igneous rocks. None of these conditions exist in the vicinity of Gatun. The rocks are of sedimentary origin and were deposited on the sea bottom at some distance from the shore in the form of sands and clays. Their subsequent hardening into rock is the result of simple cementation by calcareous solutions contained in the sea water and through pressure. Certain beds are harder than others, since the nature of their constituents favored more complete consolidation. The beds, however, are not to be regarded as unconsolidated. They are all 'rock,' though in some instances soft enough to be loosened with a pick."

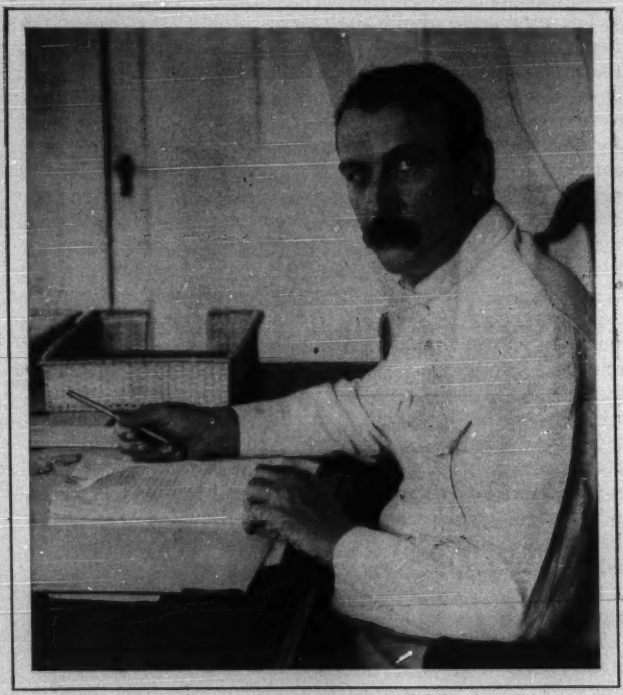
At the other *crux* of the project, the Culebra cut, near six million cubic yards of "spoil" were removed in the fiscal year. The Culebra division is about 10 miles in length, from the Chagres River, which strikes the Canal route amidships, to Pedro Miguel, on the Pacific side of the continental backbone. Last July, in 26 working days, with 43 shovels at work, 770,570 cubic yards were taken out; in August (27 working days and 40 shovels), 786,856 yards; in September (24 days, 39 shovels), the figures were

753,468. This, it must be remembered, was in the middle of the April-November rainy season, when the clay sticks to the dump-cars and the rains send the spur-tracks sliding down the faces of the cut, faster even than Mr. Bierd's wonderful "track-shifter" could transplant them.

The magnitude of the engineering achievement under the French regime will not be depreciated by anyone who has stood on the brink of the cut and watched the buzzards soaring across the abysmal space between Contractors' and Gold Hill. A seventy-ton shovel, plastered against the side of the cliff and fighting away for dear life against the mountain wall, looks about as big as a child's toy fire-engine in a shop window seen from across the street. A ninety-five-ton Bucyrus shovel at work, when you are right up close to it, or perhaps sitting on the boom, is, next to a liner full speed ahead at sea, the most inspiring piece of mechanism I know of. You feel fairly afraid that the mighty proboscis and the sharp, gleaming steel tusks on the lip of the shovel may at any moment turn and rend you, just as they are making ruin there amid the blasted basalt rock and the "indurated" clay. The ropy coils of black smoke wreathe and braid into the lifeless air from the funnel above your head; the machine staggers and rocks upon the rails, and you have to make a megaphone of both your hands for a word to the engineer. And out there on the boom sits a man, paid $190 a month, to pull the latch-rope at just the right instant so that the right mouthful will be discharged with millimetric exactitude upon the dirt train drowsing beside us in the heat-shimmer, till it is given its full complement for the dump, miles distant, maybe. When you have once seen the performance of those shovels, your doubts as to there being a canal some day between those mountain walls are laid at rest forever.

The amount of the excavation at Culebra since the United States took hold of the job (in May, 1903), is as follows, for the year ending June 30: 1904, 60,107 cubic yards; 1905, 741,644 cubic yards; 1906, 1,506,562 cubic yards; 1907, 5,768,014, making a total of 8,076,327 cubic yards. It must be borne in mind that the "lean years" were by no means unproductive, for these years of inconspicuous cubic yardage were the years when the absolutely necessary preliminary measures of sanitation, which the French neglected, were undertaken, while Congress and the newspapers cried out upon the delay in "making the dirt fly." It

was not possible to strike the stride at the very beginning, with thousands upon thousands of workmen to be fed and sheltered and acclimated; with square miles of mosquito-breeding jungle to be mowed away; with a mechanical plant to be installed for the practical solution of an engineering problem of unprecedented



John F. Stevens, Chief Engineer, succeeded by Col. Gorgas, April, 1907.

magnitude, including the removal of a mountain, picking up a river and throwing it into a basin, and the rebuilding of two cities, all as mere side issues to the main task of creating a strait from sea to sea for more than forty miles.

The highest monthly total of output attained by the French at

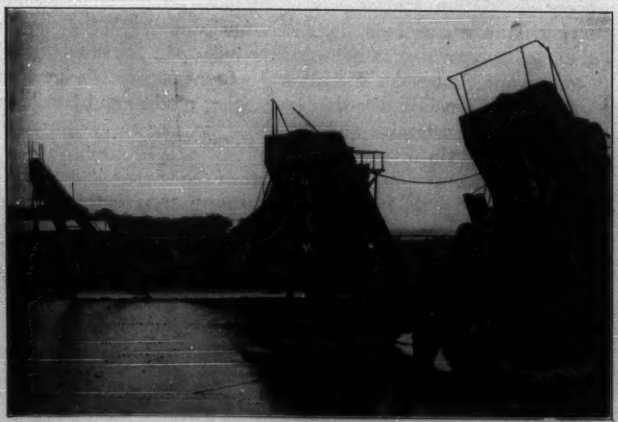
Culebra was 502,250 cubic yards, in February, 1886. In April, 1907, the American engineers got out nearly nine hundred thousand,—exceeding by 75 per cent. the record of the Compagnie Interoceanique. About 5,000 laborers, including Spaniards (the Gallegas Spaniards whom George Borrow writes about), Italians, blackmen from Jamaica, Trinidad and Barbadoes, and a few American negroes,—worked at the cut during the year. The Spaniards and the Italians got twenty cents an hour (American money) and the negroes ten. The European laborers are much better workmen than the blacks. The Jamaicans must be cajoled, they cannot be coerced, to do their work; and the kind of work they do is such as no track-foreman in the States would put up with. They stand very much on their dignity as "British objects," and the talk they can "turn loose" when the occasion arises is to the talk of a white man what the Chagres River in flood would be compared with a canary's bath-tub.

The question of contract vs. hired labor has been a vexed and vexing one on the Isthmus. In October, 1906, proposals were invited from contractors for taking over the complete construction of the canal according to the Government plans; but upon opening the bids, in January, 1907, none was found to be entirely satisfactory, and the work was retained under the pre-existing government control. The Commission is of the opinion that no one contracting concern is equipped to handle the manifold phases of the work at Panama, including not merely excavation, but dredging, dam-building, lock-construction and the relocating of a railroad. It is also represented that the government enjoys a great advantage over any private contractor in international negotiations necessary to secure laborers who are racially and temperamentally fitted for work under peculiarly trying climatic conditions. The Commission repudiates the assertion that contract labor is less likely to exceed a fixed time limit. They cite the experience of the Commission itself in contracting for supplies in the United States, and assert that the contractors have often exceeded the time limits for delivery, which the contractors themselves have set. Speaking of the Culebra work, the Commission says: "Under the circumstances no advantage would accrue to the United States by letting this piece of work to contractors, but on the contrary there would be not only additional expense, but a

The hospital, Colon.

Paving the streets, Panama.

Bachelor quarters, Culebra.



Old French bucket dredges, Colon.

feeling of unrest and dissatisfaction engendered among the present employees materially affecting efficiency. Under existing conditions, therefore, contract work cannot be recommended for the Culebra division."

The plans for the relocation of the railroad, made necessary in large part by the lake that the Gatun Dam creates, contemplate some two million cubic yards of excavation, and twelve million cubic yards of embankment. The ten million cubic yards of the excess of embankment over excavation will come from the canal prism. A new bridge will be thrown across the swirling current of the Chagres where it elbows to the north at Gamboa. And while at Miraflores and Pedro Miguel and Gamboa and Gatun the new roadbed is being piled into the jungle and the swamp, and the spruce ties from the States and the seventy-pound rails are being laid, the track will be "red-hot" with spoil-trains of Western dump-cars, and passenger trains crowded with black people in transit along the only thoroughfare. When John F. Stevens was "Chief," somebody commented on the number of wrecks. He answered, "Well, that's a sign there are trains running." It has often been said that what with the between-ship passenger traffic, the movement of construction gangs, the transport of material, the dump-trains and dirt-cars, the freight of every description, and the official "specials" white-flagging the way traffic ever and anon, there is no busier section of railroad in the United States than the forty-four miles of track constituting the Panama Railroad. Except for a four-mile stretch between Gatun and Lion Hill, the double-tracking of the road has been completed, and a block system has been installed to facilitate the work of the train dispatcher.

To take a forward look, the estimate of the appropriation needed for the fiscal year, June 30, 1908-June 30, 1909, is thirty-three million dollars. A committee of the House of Representatives, headed by Congressman Tawney, thinks it has found ways and means of saving a million dollars on this estimate, but, as the New York *Sun* has pointed out, the result of the three-day tour of inspection of this party, as compared with the impressive array of facts and figures assembled by the engineers of the Commission, makes a cheeseparing economy appear to be the penny-wise, pound-foolish policy. The Report of the Commission justifies

past expenditures, refutes the critics, and confirms the sanguine prophecies that have been made ever since the first explorers

> "Stared at each other with a wild surmise,
> Silent upon a peak in Darien."

II.

The annual ball of the Culebra club, on New Year's Eve, 1907, at the Tivoli Hotel, in Panama, was a truly brilliant affair; but at midnight while still "to the trembling string the dance gaed through the lighted hall," we left the lights and the laughter, the chiffon and the señoritas, and turned in to try to get a little sleep before the Alligator Hunt, which was due to start at 3 A.M. But just before my head sought the pillow, I stepped out on the verandah a moment in the flooding moonlight. Out on the bay the tranquil brilliant lamps of the big tramp steamers made feeble, ineffectual efforts to mock the starry glory of the Southern Cross; and the arc-lights newly planted along the streets of Panama by *los Americanos* were as if strange constellations had been spilled out upon the land. Up and down the streets the native population paraded, making night hideous with bull-hide drums and tambours and sputtering strings of firecrackers, to which the steam-whistle of the ice-plant added a wailful and long-drawn-out obligato.

At punctually 3 A.M. the black boy beat a rolling tattoo on my door, and I tumbled out. The Captain of Police—who had been up all night quelling chocolate-and-vanilla riots till the exhausted population and the tambours fell asleep over their rum with the gorgeous dawn—had brought the necessary chariots and horses to take the visiting Americans down to the long wharves at La Boca where the big iron ships, rusty from long voyages, come in to discharge their cargoes, and the eighteen-inch white terredo-worms cling with their augur-bit heads sapping away the short-lived creosoted pine timbers.

We drove at a merry rate down the cobbled quagmire of a *calle* in the outskirts of the town, the black boy yelling at his four horses as they waltzed and chassée-d at every shadow, and his long whip rained in viewless fireworks about their metal-tagged ears. He called them all by name; and they whinnied back; and so the talking to and fro betwixt the horses and their driver went

on, till we rounded the big black mole of La Boca Hill in a swirl of dust and came to a hard-breathing pause in the fading moonlight by the stringpiece of the wharf, with the old rotting hulks of French dredges moored alongside.

There the Captain had a big launch ready, the parts of which were sorted out and put together by the canal engineers who found them after the French *débâcle* lying at the top of the Culebra divide among a lot of *snow-plows!* She was a fifty-footer; and with three negroes sweating away in the engine-pit amidships, she took us at twelve brave knots an hour through the islands of the bay, with the sharks chasing the mullet clear out of water, and fleeing schools of mackerel, and pelicans sitting in judicial solemnity on the islet reefs to purse up in their pouchy gullets whatever fish went frantically shoreward among the breakers.

Twenty-five miles from La Boca, we turned and ran in where the ebb-tide was dragging seaward the drug-store chocolate waters of the Chorrera River. Right at the mile-wide river mouth, to the starboard, lay twenty-five feet of a gray-green lichened log, that seemed visibly to cringe and flatten as we ran in nearer for a shot.

The Captain's elephant-gun belched forth like Mount Pelée, and the niggers danced out of the cockpit to clap their hands and shout, as the saurian hove his front half up on pudgy legs, looked about him like a gigantic inchworm, uncertain where to lay hold next, and then shambled and slumped off the mud-flat into the water.

The launch hove to at a tiny dock, and we got into four row-boats, with two Jamaica negroes at each oar. It was a long, slow fight for headway against the current. Three corrugated noses, one after another, ferrying across from bank to bank, vanished ripplelessly under when the Captain, standing in the prow, spoke to them with the elephant-gun. And yet the Captain was not satisfied.

"Just wait till we get around the big bend of the river, boys," he said, "I'll show you a happy hunting-ground then!"

But the big bend might as well have been Cape Horn, so far as our efforts to get around it were concerned. Just here, a reef of oyster-clad rocks ran out into the river, almost from bank to bank, and in the interstices the water combed through, nine miles

an hour. The water-dogs ran out of the thickets to watch us and the paroquets gabbled like gramaphones, and even the buzzards seemed to pause mid-air in their hovering flight, when then saw we could gain no painful inch, and stood practically still amid-stream, with the noon sun blazing down. But our voices disappointed the carrion-hunting birds, in their hopes of finding lifelessness where we were.

"All out on the rocks!" commanded the Captain, and then to the blacks he said, peremptorily, "Take out the guns and the grub, and lift the boat over."

Even then it was not easy. There were bleeding feet among the thwarts when we got in again,—and bleeding hands, too, for those who tampered with the sharp-edged oysters, thinking to make a luscious meal. But with hurrahs and yells we swept gradually round the bend, all four boats abreast, and then—"By Jupiter!" shouted the Captain. On a wide, flat mud-bank to the left was a leviathan convention of about twenty-five (there are those who insist on at least two hundred). The patriarch of the lot lay like a fallen live-oak bearded with Spanish moss and lichens, encrusted with barnacles, hoary with eld. The rest, nestling in his lee, reminded one of a wrecking company's tugs trying to rescue a stranded ocean steamer.

Then it was like the Wild West Show when the Deadwood coach comes in—everyone banging and blazing away in utter disregard of his neighbor,—a dozen 44-caliber Marlin rifles bringing down green cocoanuts on the bank, nicking the bark from floating logs, ruining rare orchids, and driving the astonished sandpipers to their nests among the reeds—only the Captain, standing in the prow of the foremost boat with his elephant gun at his shoulder, his bronzed face impassive, trying to marshal the ague-stricken little army of marksmen, was doing any real execution.

Suddenly there was a stir in the bushes, and a big alligator waddled down the bank toward the Captain's boat, her lower jaw wagging and clapping like the lid of the bucket of one of the ninety-five ton steam shovels in the rock-cutting at Culebra. The Congressman from California poked the nose of his kodak between the Captain's legs. On came the saurian, and the Congressman from California pressed the button again and again. At the last minute, just as the indignant lady 'gator was about to climb into the boat and rebuke the kodak-fiend emphatically, the

Captain fired. The 'gator rolled over into the water, squirming in death agonies, lashing the water into a bloody froth with her ten-foot tail.

"Now, get out there with a rope," yelled the Captain to the bow oarsman, "and make a slipnoose round the upper jaw, and drag 'er ashore!"

The elephant gun spoke again,—she would have dislocated an ordinarily strong man's shoulder with every one of her remarks,—and by the time the boatman's noose was ready the great beast lay quite dead with her back humped out of the shoal water, making a little lagoon betwixt herself and the shore.

The Congressman from California crawled out from between the Captain's legs, and a black bottle with a garish label came rapidly his way from the bowels of the boat.

I saw the photographs afterward, when the Congressman developed them—or it. For it is all one picture. He forgot in his excitement, to unroll the film after pressing the button, and there are more alligators in the composite photograph than there were in the entire herd when the Wild West Show began.

BY-PRODUCT COKE FOR DOMESTIC FIRES.

In a paper read by Paul Schlicht before the Society of Arts at London, May 8, an earnest plea was made for the use of coke in domestic fires, and particularly for coke made in by-product ovens, by which certain quantities of inflammable gas are left in the fuel, rendering it more flaming than that turned out in the ordinary way. The use of bituminous coal in domestic fires was condemned as being very wasteful, for about fourteen times the air necessary to burn the coal was generally sent out the chimney. This is impregnated with steam and sulphuric acid, as well as with particles of carbon, which produced fog. In addition to this, in the consumption of every ton of coal 100 lbs. of coal tar are destroyed; also many valuable constituents useful in the arts and in medicine, besides oils useful for lighting and motor purposes, together with solids that might be employed in road-making. If in place of such form of combustion the coal were treated in the modern by-product oven, there would be, in addition to the products named, about fourteen cwt. of coke, suitable for domestic and metallurgical purposes. Flaming coke can be made in the by-product ovens in from four to five hours less time than the low volatile coke required for metallurgical purposes, a certain percentage of hydrogen and hydrocarbons being allowed to remain in the coke.—*Eng. and Min. Jour.*

(*Stated Meeting held Wednesday, November 20, 1907.*)

"Note on Old Wire Suspension Bridge, Callowhill Street, Schuylkill River, Philadelphia."

By Strickland L. Kneass, C.E.

One of the features of interest to Philadelphians of a generation or two ago, was the picturesque and graceful wire suspension bridge which spanned the Schuylkill River at Callowhill Street, just below the Fairmount Dam and Water Works.

Flanked on the eastern side by the old Water Tower of the Fairmount Reservoir, its graceful outline and easy curves formed a pleasing foreground against the wooded banks of the river. This bridge was designed and constructed by Charles Ellet, Jr., a well known engineer in the early forties, and was built upon the site of the former wooden arch bridge of 340 feet 3¾ inch span, ver-sine 35 feet, designed by L. Wernwag in 1812 and destroyed by fire in 1838. The suspension bridge of Mr. Ellet was later replaced by the iron truss, now extant. A preliminary investigation for the erection of the abutments of the present structure, developed some interesting facts in regard to the condition of the Ellet bridge.

At the intersection of Callowhill Street extension and the Schuylkill River, the rock stratum at the western bank is 37 8/10 feet below city datum, necessitating the use of piles for the support of the abutments. The Ellet towers were built upon the old abutments of the 1812 bridge, after a careful investigation had been made as to the security of the piles and grillage. At the eastern approach, the abutments were built directly upon the rock, which at this point is six feet below the datum plane. The square granite towers were 28 feet 10 inches high, 8 feet 6 inches at the base and 5 feet at the top, supporting a cap stone 4 feet 3 inches square, carrying cast-iron rollers for the cables. Five sustaining

cables were provided at each side, 27 feet apart at the center of the span and 36 feet apart between the towers. The wire was made of charcoal iron, manufactured at the Freedom Forge, Mifflin County, Pa.; each cable was 2 21/32 inches in diameter and contained 258 strands of 5/32 inch wire, with a loop at each end which was secured to the anchorage links. At intervals of 18 inches it was wrapped for a distance of 3 inches with fine wire 1/25 of an inch in diameter. The suspenders were formed of wire of the same diameter as those of the main cable, viz.: 5/32 of an inch and in similar way, and consisted of from 24 to 30 strands. The platform was stiffened by a wooden truss of the Howe pattern. When the cables were removed to make way for work on the super-structure of the present bridge, specimens of the constituent strands were sent to the Department of Engineering of the Stevens Institute and were tested by Dr. R. H. Thurston. His report showed that the tensile strength was remarkably uniform and that the surfaces were in good condition and but slightly oxidized. The tensile strength of the wires was found to be 90,000 pounds to the square inch of the original section and were reported to be as good, strong and ductile as the best wire of similar section made at the time of the test in 1875. The tracing herewith shows the details of construction of this bridge, all of which will probably be of interest. Considering the time at which it was built, it shows care in design and workmanship, although it is probable that the link connection between the cables and the anchor chains, could have been more efficiently constructed. This old bridge was a picturesque feature of the Park, and it is unfortunate that during late years but little consideration has been given to graceful lines and æsthetic taste in the design of structures which have since been erected to span the Schuylkill River within the city limits, and thus many opportunities for adding to the natural beauties of our water way, have been lost.

JOHNSON, MATTHEY & Co., Ltd., of 48-81 Hatton Garden, London, have succeeded in producing iridium and rhodium of such extreme purity as to render these heitherto practically unworkable metals so malleable as to enable their being used for the manufacture of such apparatus as basins, tubs, and flasks. These metals, having a very high melting point, and being almost unattacked by acids, should prove of gr at value in chemical research.—*Eng. and Min. Jour.*

ELECTRICAL SECTION.

(Stated meeting held Thursday, October 10, 1907.)

(*Concluded from vol. clxiv, p. 459*)

The Electro-Thermic Production of Iron and Steel.

By Joseph W. Richards, Ph.D.

Professor of Metallurgy in Lehigh University; Professor of Electro-chemistry in the Franklin Institute; Secretary of the American Electrochemical Society.

PROBLEM 3.

An electric furnace is charged with Lake Superior hematite (90% Fe^2O^3, 10% SiO^2) mixed with pure SiO^2 sand, and with Anthracite coal (90% fixed carbon, 10% ash—which may be assumed SiO^2). The alloy produced is 50% Si and 50% Fe. The liquid alloy runs from the furnace at 1600° C., carrying 461.5 Calories per kg. The gases pass off at 500° C., and contain CO and CO^2 in the proportions of 1 to 2, by volume. One-fifth the energy of the current is lost by radiation from the furnace and conduction to the ground.

Required:—

(1) A heat balance sheet of the furnace, per metric ton of alloy produced.

(2) The electric energy necessary to produce a metric ton of alloy.

(3) The electric current required to produce one ton of alloy per hour.

Solution:—

(1) Oxygen given off by SiO^2 $500 \times {}^{32}/_{28} = 571$ kg.
" " " Fe^2O^3 $500 \times {}^{48}/_{112} = 214$ "

" " " Charges = 785 "
Ratio of CO to CO^2 by volume = 2
" " ⊙ to C in gases, by weight = 1.75
Fixed carbon required = 785 ÷ 1.75 = 449 kg.
Coal used = 447 ÷ 0.9 = 499 "
SiO^2 necessary in furnace = 500 + 571 = 1071 "
" in ash of coal = 50 "
" in ore used = 714 × ${}^{1}/_{9}$ = 79 "
" sand necessary = 1071 − (50+79) = 942 "

HEAT DISTRIBUTION.

	Calories.
Heat in melted alloys	= 481,500
" hot gases, at 500°:	
CO 616 m^3 × 240 = 147,840	
CO^2 308 " × 156 = 48,050	
	= 195,890
Heat for reductions:	
SiO^2 500 × 7595 = 3,797,500	
Fe^2O^3 500 × 1746 = 873,000	
	= 4,670,500
Radiation and conduction	= X
Total heat requirement = 5,347,890 + X Calories.	

HEAT AVAILABLE.

Oxidation of C to CO^2	
166.3 × 8100 =	= 1,347,040
Oxidation of C to CO	
332.7 × 2430 =	= 808,460
Energy of electric current	= 5 X
Total heat available = 2,155,500 + 5 X Cal.	
Whence, equating these, X = 793,100 Cal.	
and 5 X = 3,965,500 "	

(2) The electric energy is obtained by noting that the kilowatt-hour represents 860 Calories, if entirely converted into heat energy. We therefore require, to produce one metric ton of alloy

$$3{,}965{,}500 \div 860 = 4{,}610 \text{ kilowatt-hours.}$$
$$= 0.526 \quad \text{“} \quad \text{-year.}$$

(3) To produce one ton of alloy per hour would require current equal to 4,610 kilowatt capacity.

ENERGY REQUIRED FOR REDUCTION.

Two extremes are possible in the reduction of iron oxide; first, that only CO gas results; second, that equal volumes of CO^2 and CO result. This last proportion is only attained by having the maximum possible amount of reduction by CO gas. The chemical formulæ are:

$$Fe^2O^3 + 3\,C = 2\,Fe + 3\,CO.$$
$$Fe^2O^3 + 2\,C = 2\,Fe + CO + CO^2.$$

The relations are very simple. For 112 parts of iron set free and 48 parts of oxygen taken up by the carbon, there is required either 36 or 24 of carbon, and the heat generated by the oxidation of the carbon set free against the heat required to reduce the Fe^2O^3 is

Case 1:

Reduction of Fe^2O^3	= 195,600	Calories
Formation of 3 CO	= 87,480	“
Deficit	= 108,120	“

Case 2:

Reduction of Fe^2O^3	= 195,600	“
Formation of CO = 29,160		
“ “ CO^2 = 97,200		
	= 126,360	“
Deficit	= 69,240	“

Thus, although only two-thirds as much carbon is used in the second case as in the first, yet 44 per cent. more energy is gotten from it, and the deficit to be made up electrically is reduced 38,880 Calories.

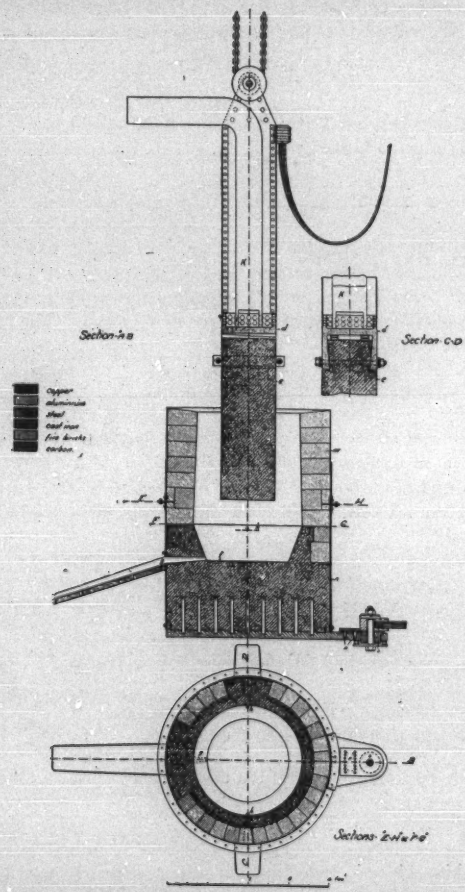


Fig. 12. Electrical furnace used at Sault Ste. mine for reducing iron ores to pig-iron.

If we assume that the product is pig-iron with 95 per cent. of iron, and 4 per cent. carbon, there will be a heat deficit per 100 kg. of pig iron of

$$108{,}120 \times \tfrac{95}{112} = 91{,}710 \text{ Calories in Case 1.}$$
$$69{,}240 \times \tfrac{95}{112} = 65{,}780 \quad \text{“} \quad \text{“} \quad \text{“} \quad 2.$$

and the fixed carbon in the reducing agent used must be

$$(36 \times \tfrac{95}{112}) + 4 = 34.5 \text{ kg. in Case 1.}$$
$$(24 \times \tfrac{95}{112}) + 4 = 24.4 \text{ “} \quad \text{“} \quad \text{“} \quad 2.$$

The amount of coke, charcoal or anthracite used must depend on its percentage of fixed carbon Thus, taking petroleum coke at 99 per cent. fixed carbon, coke 90 per cent., anthracite 95 per cent., charcoal 92 per cent., there would be required per 100 of pig-iron made:

	Petroleum Coke	*Anthracite*	*Charcoal*	*Coke*
Case 1.....	34.9	36.3	37.5	38.3
Case 2.....	24.7	25.7	26.5	27.1

The electric current must make up the deficit in the heat of the reduction, must supply all the sensible heat in the slag and pig-iron, decompose carbonate of lime used as flux, drive off moisture and volatile matter from charges, supply the sensible heat in the waste gases, and supply radiation and conduction losses.

Heat in Slag: This will vary with the weight of slag and its temperature at tapping. It will be not less than 400 Calories per kilogram, and may easily reach 600. The weight of slag per 100 kg. of iron will vary with the amount of gangue in the ore and the kind of slag made, *i. e.*, the amount of limestone added to flux it. This weight may be very variable, it may be from 15 kilos of slag from rich ore to as much as 100 for poor ore. This heat requirement must be worked out for each specific case.

Heat in Pig-Iron: This would scarcely ever be less than 300 Calories per unit, and might easily run up to 400.

Heat in Waste Gases: This depends on the amount and temperature. They may escape as hot as 1000° C., which would be very crude practice. They might be cooled to 100° C., which would be very good practice.

Heat to Evaporate Moisture: This is 606 Calories per unit of moisture evaporated. A preliminary drying is of advantage thermally, but a damp charge will form less dust.

Heat to Decompose Carbonates: This is 1026 Calories per unit of CO^2 driven off limestone; 846 from dolomite. It may amount to a large item if much raw flux is used.

Heat Conducted to the Ground: This will be very variable, according to the size of the furnace, and it may be 10,000 Calories per 100 kg. of iron produced, and in other cases two or three times that much.

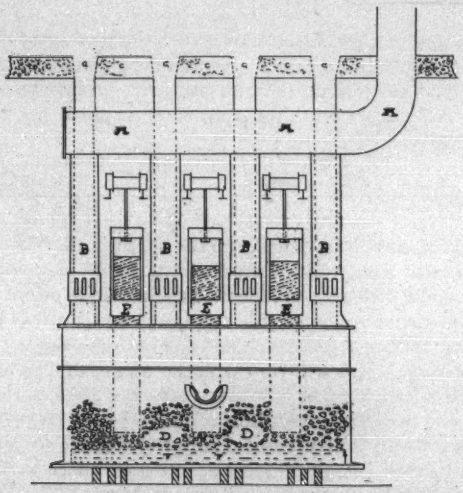


Fig. 13. A tri-phase electric furnace of 2000 H. P. used in Shasta, California, for the production of pig-iron.

Heat Conducted to the Air and Radiated: This may be as low as 10,000 Calories per 100 kg. of pig-iron, and again may be 50,000, in a small furnace poorly designed.

Reduction of Other Metallic Oxides: These may form an important part of the charge, and the heat required to reduce silicon, manganese, and phosphorous may be quite large; also the reduction of CaO to form CaS is not to be neglected on a high sulphur charge.

REDUCTION OF IRON ORES.

The Canadian Government appointed a commission in 1905 to report on the possibilities of the electrical production of pig-iron, and in 1906 gave it authority to supervise experiments to determine the feasibility of this matter as applied to Canadian ores. The experiments were carried out under the supervision of Drs. Haanel and Héroult, and were the subject of an elaborate report. Since the writer has gone into an extended discussion of these experiments and their teachings, in a paper read at the Twelfth General Meeting of the American Electrochemical Society, and to be published in Vol. XII of that Society's Transactions, the discussion will not be repeated here. Suffice it to say that several hundred tons of pig-iron were made from hematite and magnetite ores, in an electrical furnace of the type shown in elevation and plan in Fig. 13, showing the possibility of producing a ton of pig-iron by about 0.25 H.P. years of electrical energy, and demonstrating the commercial practicability of the operation in favorable localities. Later, Dr. Héroult has erected for Mr. Nobel, in Shasta County, California, a 2,000 H.P. tri-phase furnace, shown diagrammatically in Fig. 14, which started in operation July 4, 1907, and is in reality the pioneer electric pig-iron furnace of the commercial world. The whole subject is in an elementary, but nevertheless a very rapidly developing stage.

PROBLEM 4.

Assuming 100 kg. of an ore containing 9% Fe^2O^3 and 10 SiO^2, fluxed by addition of 18 $CaCO^3$ and reduced by 20 of petroleum coke. Pig-iron 95 Fe, 4 C, 1 Si.

Required: The probable electric energy requirement per metric ton (1000 kg.) of pig-iron made.

Solution:

Ore needed

$$950 \div (0.90 \times 0.7) = 1508 \text{ kg.}$$

Oxygen from reduction

$$950 \times \tfrac{48}{112} = 407$$
$$10 \times \tfrac{32}{56} = 14$$
$$\text{——} \qquad 421 \text{ kg.}$$

Oxygen from $CaCO^3$

$1508 \times 0.18 \times {}^{16}/_{100} = 43$ "

Sum = 464 "=O in gases.

Carbon from coke

$1508 \times 0.20 \times 0.99 = 299$ "

Carbon from flux

$1508 \times 0.18 \times 0.12 = 21$ "

Total C in furnace = 320 "

" C in pig-iron = 40 "

" C in gases 280 "

Gases formed

$280 \div 0.54 = 519$ m³ CO & CO^2

$= 126$ " CO^2

$= 393$ " CO

Heat of oxidation of carbon

CO $212 \times 2430 = 515,160$ Cal.

CO^2 $47 \times 8100 = 380,700$ "

895,860

Reduction of Fe: & Si:

$950 \times 1726 = 1,639,700$ "

$10 \times 7500 = 75,000$ "

1,714,700

Deficit, 818,840 Cal.

Decomposition of $CaCO^3$.

$56 \times 1026 = 57,450$ "

Heat in Slag:

$282 \times 500 = 141,000$ "

Heat in Pig-Iron:

$1000 \times 350 = 350,000$ "

Heat Conducted: = 200,000 "

Heat Radiated: = 300,000 "

Heat in Hot Gases at 500°:

CO^2 $126 \times 240 = 30,240$

CO $393 \times 155 = 61,915$

92,150 "

Net Heat to be supplied: 1,959,440 "

$$\textit{Kilowatt-hours} = \frac{1{,}959{,}400}{860} = 2280 \text{ per ton of pig-iron.}$$

$$\textit{Kilowatt-years} = \frac{2280}{8760} = 0.26 \text{ k.w. year.}$$

REDUCTION OF IRON ORE.

This is really only a special case of the ferro-alloy practice, since if the other metallic oxides are left out we can get cast-iron, steel or pure iron, according to the excess of carbon used. Iron oxides are reduced in the blast furnace principally by CO gas formed by combustion before the tuyeres. The reaction usually lies between these two equations:

$$Fe^2O^3 + 9\,CO = 2\,Fe + 3\,CO^2 + 6\,CO.$$
$$Fe^2O^3 + 6\,CO = 2\,Fe + 3\,CO^2 + 3\,CO.$$

These reactions require either 9 C (108 parts) or 6 C (72 parts) to be burned at the tuyeres for every 2 Fe (112 parts) of iron produced. This means that the fuel used must be some 75 to 100 per cent. of the weight of the iron produced. Modern practice averages 100 per cent., more is commonly used in producing high silicon iron, and less is attained usually only with pure fuel and purer ores than the average.

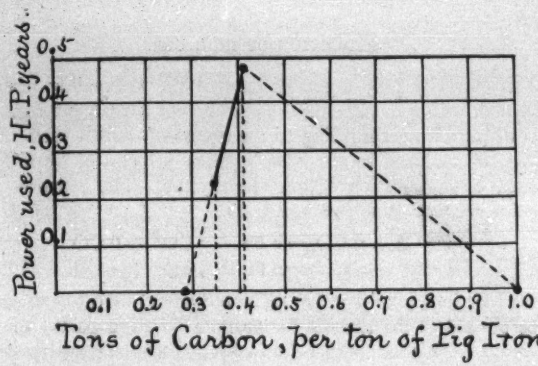
In the electric furnace there is no blast, and the 6 CO or 9 CO noted above as formed by combustion at the tuyeres can be assumed as formed by *reduction* of iron oxide at the hottest part of the furnace. The reaction would be:

$$3\,Fe^2O^3 + 9\,C = 6\,Fe + 9\,CO.$$
$$2\,Fe^2O^3 + 6\,C = 4\,Fe + 6\,CO.$$

This means that for a given weight of carbon used in the two furnaces, the electric furnace ought to turn out three to four times the weight of iron (8 Fe or 6 Fe instead of 2 Fe), or for a given weight of iron produced that only $\frac{1}{3}$ to $\frac{1}{4}$ as much carbon need be used, or say 25 to 35 per cent. of the weight of iron made. $\frac{1}{3}$ to $\frac{1}{4}$ of 75 to 100 per cent.

These figures are fully borne out in practice, in that experi-

ments have approximated these requirements. For instance, at Livet 0.34 tons of coke was used per ton of pig-iron produced, but considerable iron and manganese remained in the slag. In another experiment 0.41 tons was used, with still iron and manganese left in the slag. In the first case 0.226 electric horse-power years was used per ton of iron produced, in the second, 0.475. If we plot these figures we have



The dotted line at the right is hypothetical, but is intended to suggest the fact that about one ton of carbon per one ton of iron made is needed if no electrical power were used. The hypothetical dotted line to the left is simply an extension of the line giving the two points for which data were plotted. We see it striking the axis of abscissas at 0.28. This suggests very strongly the idea that 0.28 carbon per ton of pig-iron is the quantity which is to be approached as the efficiency of the furnace is increased. For instance, if the furnace could be run on 0.1 H.P. year, the carbon required would probably be simultaneously reduced to 0.30 ton per ton of pig-iron. This statement really puts the cart before the horse; it should properly read: if the furnace by proper design and running, was run with 0.30 ton of fuel for reduction per ton of pig-iron, the power consumption would probably be reduced to 0.10 H.P. year per ton of product.

These figures appear anomalous. It seems like saying—leave more for the electric current to do, and it takes less current to do

it. The explanation of the paradox is that in the first place, the electric current does not perform any reduction in either case or in any case. So that decreasing the carbon used does not put any more work of reduction on the current; and in the second case the carbon is burned in larger proportion to CO, thus giving not only more heat per unit of carbon but actually giving *more* heat from the smaller weight of carbon than was produced in the first case from the larger weight. By using less carbon (within limits, of course,) we actually get more heat generated by its oxidation, and therefore can get along with *less* electrical energy.

The point to be recognized and kept clearly in mind is that a given weight of iron reduced liberates a given weight of oxygen. We have approximately 0.4 ton of oxygen set free for a ton of pig-iron produced. If this burns carbon only to CO, it can burn 0.3 ton of carbon, and give off in doing it 729,000 Calories. If it burns carbon half to CO and half to CO^2, it can burn only 0,225 tons of carbon, but it will generate in doing it 972,000 Calories. If it could possibly burn carbon all to CO^2 (it cannot, as far as we know, under these circumstances) it could burn only 0.15 ton of carbon, but would generate thereby 1,215,000 Calories. We therefore reach the important conclusion, that the less carbon is used in the electric furnace reduction of iron ore the more heat will be generated by its combustion, and the less electric energy will be required; within the limits, of course, of using enough carbon to perform reduction.

The key-note to economy in electric furnace reduction of iron-ore is the reduction of the carbon in the charge to the lowest possible minimum. This will coincide with the largest possible production of CO^2 in the furnace gases, and the analysis of the escaping gases will give an exact criterion of the running of the furnace. It will also coincide with the minimum of electrical energy needed to run the furnace.

How can these conditions be attained? By studying the design of the furnace, and particularly the conditions favoring the reduction of iron oxide by CO gas, and formation of CO^2. These are: slow passage of gases through the charge; high column of charge; uniform but small size of the pieces of charge material; absence of dust or fines in the charge. Electro-metallurgical engineers should give their best attention to the study of these conditions and their accomplishment. If this is

coupled with a study of the best shape of the furnace, and the best means of reducing radiation and conduction losses, the minimum of carbon required, and of electrical energy necessary will be attained. These are considerably below what is now being reached in the crude, imperfect "first attempts" which are doing service at present—furnaces which are in point of technical development comparable to the Philippine Islands' crude blast furnace. They are no more like the electric furnace which is shortly to be, than the old charcoal furnace of Dud Dudley, which made fifteen tons of iron a week, is like a modern Edgar Thompson giant. But there will not be two centuries between, this time,—two decades will suffice.

ALUMINUM COATED CONDUCTOR PIPE, EAVES TROUGH, ETC.

Reeves Mfg. Company, Canal Dover, Ohio, is putting on the market a new line of aluminum coated conductor pipe, eaves trough, elbows and shoes, &c., which it declares to be rustproof, not affected by acid fumes and requiring no painting. It is also declared that the product will solder freely and will double seam without scaling. The company claims for these goods the rustproof qualities of aluminum and the wearing qualities of copper, although they cost about one-third as much as copper, and puts them out with the guarantee to replace them if they rust out at any time within twenty years.

THE approximate horsepower of gas engines may be calculated by empirical rules formulated by Dugald Clerk, the eminent British authority. He uses two rules, one for engines not exceeding twelve horsepower and the other for larger engines. In both formulas, D represents the diameter of the cylinder in inches, and N the number of cylinders. The mean effective pressure and the piston speed being about constant, are taken care of in the constants used in the expressions. For the smaller type the formula is

$$\text{Horsepower} = \frac{D^2 \times N}{3},$$

while the larger type uses the same formula, but the constant becomes 2.4 instead of 3, as used in the denominator. The mean effective pressure in each case is assumed to be 70 lbs. per square inch, while the piston speed is 800 feet per minute for the smaller engine, and 1000 feet for the larger.—*Iron Age.*

Section of Photography and Microscopy.

(Stated meeting held Thursday, November 7, 1907.)

Radio-Active Minerals Found in Pennsylvania and Their Effect on the Photographic Plate.

By Edgar T. Wherry.

Of the many wonderful properties possessed by radio-active bodies, perhaps none is more striking and characteristic than the power of emitting rays, which, passing through even considerable thicknesses of opaque matter, will affect and leave a definite record of their existence upon a photographic plate. It was, indeed, through this property that the very existence of radio-activity was originally discovered, over ten years ago. Becquerel, it will be remembered, was following up the observation of Niewenglowski that calcium sulfide, in phosphorescing after exposure to sunlight, gave out radiations which acted upon a sensitive plate enclosed in thick black paper, and was repeating the experiment using uranium nitrate as the phosphorescent substance. By accident, the uranium salt was left upon the plate for some time, without having been exposed to the sun at all, and it produced an image just the same. From this small beginning, through the brilliant researches of the many able investigators who have applied themselves to the subject, the vast series of radio-active phenomena has been gradually unfolded to our view.

All of the artificial uranium salts having proved to be photographically active, experiments were next directed to natural compounds of the metal, and pitch-blende was found to yield a stronger effect than any substance previously known. The work

of the Curies upon this mineral, culminating in the separation of pure radium compounds, is now so familiar to everyone that it needs but passing mention. Pitch-blende, however, was by no means unique in its power of affecting the plate,—many other minerals were soon found to possess similar properties.

The most exhaustive of the early studies of this phase of the subject was undoubtedly that of Crookes who, in 1899-1900, went through every mineral in his cabinet—"a somewhat extensive collection, numbering many fine specimens"—and published a list of sixteen species which he found to be active.* Several other lists have since been published,† until now over a hundred minerals are known to yield photographic effects.

In the State of Pennsylvania, and especially in the southeastern portion, uranium-bearing minerals are by no means uncommon At present writing some fifty localities are known from which nearly twenty different species have been obtained, and every now and then new finds are reported. These occurrences are confined almost exclusively to the areas of highly metamorphosed schist and gneiss of our region, being especially numerous where pegmatites are developed, as in southern Delaware County, although they are not infrequent in the City of Philadelphia itself. As the same minerals from other localities had been repeatedly observed to affect the plate, it occurred to the writer that it would be interesting to endeavor to obtain similar results with some of these local specimens, and accordingly the study about to be described was undertaken.

The early writers are strangely silent regarding the details of the methods they employed. Becquerel says simply,‡ "A Lumiere photographic plate—gelatino-bromide—is enveloped in two sheets of very thick black paper." Bardet§ also uses Lumiere plates and an "energetic developer, such as metaquinone and formosulfite." But not one of the many other contributors

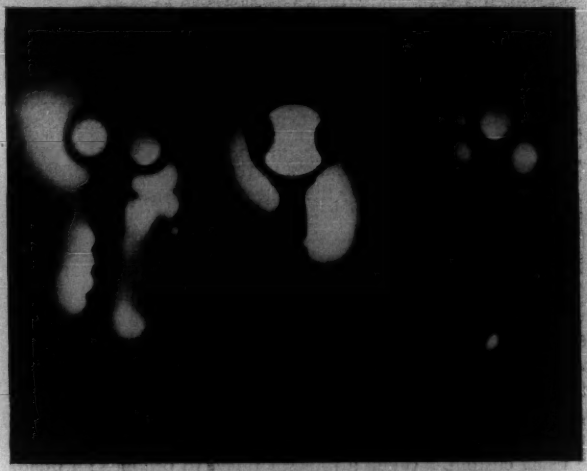
*Radio-activity of uranium. Proc. Roy. Soc., **66**, 1900, 409-423.

†The most complete is that of Pisani: Examen de plusiers minéraux au point de vue de leur radio-activité. Bull. Soc. Min., **27**, 1904, 58-63.

‡Sur les radiations émises par phosphorescence. Comptes Rendus **122**, 1896, 420.

§Essai de mesure de l'activité photographique de certains minéraux. Bull. Soc. Min., **27**, 1904, 63-66.

PLATE I.



(11) (8) (3. W.)

Figure 1. Radiographs from the most powerfully active minerals. Slightly reduced. Exposure 5 days. Note penetration of key at the right.

Figure 2. Natural Radiographs. [See page 74] Crystals of Cyrtolite from Morgan, Delaware county, surrounded by radiating cracks in the granular quartz rocks. Three times enlarged.

to the subject mentions the character of plate or developer used, leaving it to be supposed that, after all, variations in these would probably make no difference in the final result. Actual trial soon showed, however, that the kind of plate employed is, indeed, a very important matter. After experimenting rather extensively with the various grades on the market, Cramer's X-ray plates were finally selected as best suited to the purpose.

The method of protecting the plates with black paper, as used by most of the previous workers, was here adopted throughout. The alternative of placing the specimens directly on the plate and then enclosing the whole in a light-tight box did not appear expedient, for the possibility of injury to the sensitive film and of a direct chemical effect of the substances themselves would introduce a considerable element of uncertainty into the results. The black paper used consisted of the envelopes supplied with the X-ray plates, the manipulation of which is so obvious that it needs no special description.

In regard to the time of exposure it seemed wise to depart from the usual custom. When a mineral failed to produce an image after two or three days' exposure, it had ordinarily been considered inactive. But as it appeared probable that many of the specimens under investigation would contain only extremely minute traces of any active constituents, and as there could be no objection to longer exposure on theoretical grounds, the effect was tried of leaving them on the plates for several weeks. It was then found that if the X-ray plates were allowed to remain in the envelopes for much longer than a month they would gradually undergo a decomposition, so that when developed they would be evenly covered by a stain of metallic silver. Three weeks was finally chosen as the most suitable time of exposure for the weakly active minerals, for in that period most of them would show a distinct and definite result.

The development of the plates required less consideration, although here also the lack of published data made repeated trials necessary; the developer finally selected contained two parts of metol to one of hydrochinon, and was made about twice the usual strength. After remaining in this for about ten minutes, until the image began to fade away, the plates were fixed and finished as usual.

Details concerning the specimens used and the results obtained

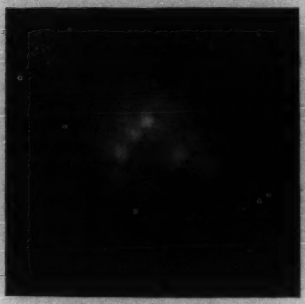
are presented in tabular form on succeeding pages; but a brief discussion of the experiments will not be out of place here. The minerals studied may be divided into two groups, according to their uranium content. The first group includes those like uraninite, gummite, autunite, etc., which contain 50% or more of the metal. These showed, naturally, a very high degree of activity, and yielded distinct prints in one hour's exposure. In fact, in one trial a perceptible image was produced by the Avondale uraninite in fifteen minutes. Such prints, however, were too faint for reproduction, and those shown in the plates below represent exposures of five days. Figure 1, in plate 1, was made with the three most active specimens, using iron keys about one millimeter thick. The penetrating power of the "rays" is clearly visible in the picture at the right, the position of each fragment of uraninite along the shaft of the key being indicated by a bright spot.

Besides these uranium compounds, every mineral known to contain columbium, the rare earths, zirconium, titanium or tungsten was tested by a three weeks' exposure. The columbates all proved to be active, though mostly only faintly so. The euxenite from Morton gave, to be sure, a very strong print, but probably contains 10% or more of uranium. In this connection it is interesting to note that the columbite from Mineral Hill, containing, according to Genth's analysis, .18% of uranium oxide, is much less active than specimens of the same mineral found at Morton and at Broad and Olney Avenue, Philadelphia. Unfortunately, quantities of these latter two sufficient for analysis have never been found, but it is possible that their uranium content is greater.

Of the rare earth minerals, monazite showed considerable activity, but then it almost certainly contains thorium and possibly uranium also. Allanite usually yielded a distinct print, but this is also probably to be ascribed to the presence of thorium. Lanthanite gave a negative result. Zircons were in most cases faintly but distinctly active, the variety cyrtolite (which may contain thorium and uranium) yielding the strongest effects.

Although many specimens of rutile—titanium dioxide—were examined, not one of them gave the slightest indication of activity. Titanite was also inactive in all but one or two cases. On account of the similarity of tungsten to uranium a specimen

PLATE II.



(3 V.) Uraninite. Avondale A.
(5 days)

(8) Gummite. Avondale A.
(5 days)

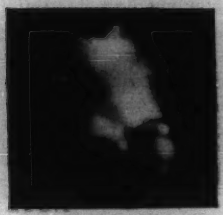
(12) Uranochre.
Avondale A.

(16) Randite.
Frankford A.

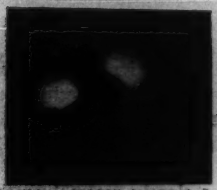
These and all that follow, were exposed 3 weeks.

PLATE III.

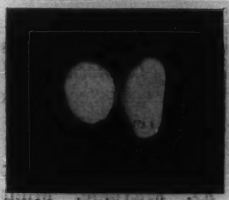
(17) Autunite.
Mt. Airy.



(34) Torbernite.
Leiperville.



(87) Columbite.
Morton.



(44) Euxenite.
Morton.

of scheelite from Frankford was tried, but it gave no effect whatever. The radio-activity of potassium, recently observed by Campbell and Wood,* has not been confirmed, for orthoclase, though frequently appearing as the gangue of very active minerals, has never produced the slightest print. Typical prints of these various minerals are shown in the plates.

It is to be concluded, then, from these experiments that uranium and thorium must be present in order that a mineral should show photographic activity. Whether produced by these metals themselves or by some associated substance, such as radium, there is no evidence to decide. The object of this communication will be attained if it shall have been demonstrated, beyond all question, that many minerals found in the State of Pennsylvania possess definite radio-active properties.

NOTES ON THE TABLE.

The accompanying table contains not only all of the minerals which have given definite proof of their radio-activity, but also those which, although specimens for experiment could not be obtained, might reasonably be expected to show analogous properties.

The identification of the minerals used has been in some cases rather uncertain on account of the small amount of material obtainable. Several of the names assigned are therefore to be regarded as provisional only, and are so indicated by interrogation marks (?). These are as follows:

9-15. *Uranochre.* Under this heading are included several yellow uranium compounds appearing as more or less amorphous or pulverulent coatings. Most of them are probably silicates (uranophane), but some may be sulphates (uraconite).

46. *Fergusonite.* Not seen.

47. *Microlite.* Minute brown grains closely resembling the Virginia microlite.

48. *Samarskite.* Small grains with the brilliant sub-metallic luster of this mineral.

*Radio-activity of the alkali metals. Proc. Cambridge Philosophical Society, 14, 1906, 15-21.

PLATE IV.

(54) Allanite. East Bradford.

(61) Monazite.
Boothwyn.

(86) (87)

Cyrtolite. Boothwyn.
(86) 12 brown crystals.
(87) 6 yellow crystals.

Tabular List of Radioactive Minerals Found in Pennsylvania.

No.	Species	Principal Constituents	Minor Constituents	Locality
1	Uraninite	U.	Pb, Ba, Ra.	Fairmount
2	"	"	"	Swarthmore
3	"	"	"	Avondale A
4	"	"	"	Chester
5	Gummite	"	Pb, Ca, H_2O	Mt. Airy
6	"	"	"	Llanerch
7	"	"	"	Swarthmore
8	"	"	"	Avondale A
9	Uranochre ?	"	H_2O	Mt. Airy
10	"	"	"	Broad & Olney
11	"	"	"	Fairmount
12	"	"	"	Avondale A
13	"	"	"	Leiperville
14	"	"	"	Chester
15	"	"	"	Mauch Chunk
16	Randite	U, Ca, C.	——	Frankford A
17	Autunite	U, Ca, P.	——	Mt. Airy
18	"	"	——	Broad & Olney
19	"	"	——	Girard Ave
20	"	"	——	Fairmount
21	"	"	——	Llanerch
22	"	"	——	Avondale A
23	"	"	——	Leiperville
24	"	"	——	Upland
25	"	"	——	Chester
26	"	"	——	Mauch Chunk
27	Torbernite	U, Cu, P	——	Mt. Airy
28	"	"	——	Mermaid
29	"	"	——	Wingohocking
30	"	"	——	Fairmount A
31	"	"	——	Fairmount B
32	"	"	——	Jenkintown
33	"	"	——	Avondale A
34	"	"	——	Leiperville
35	"	"	——	Chester

No.	Discovered By	Date	Reference	Source.	Descript'n
1	Prof. A. P. Brown	——	Priv. Com.	—	—— —
2	W. (the writer)	1906	Min. Coll., *13*, 173	W	Small grains A
3	T. D. Rand	(1892)	P.A.N.S., *1892*, 194	V, W	Fine cubic xls A
4	T. D. Rand	(1874)	Min. Penna., 43	—	—— —
5	W.	1907	——	W	Minute speck C
6	Mr. E. S. Law	1905	Min. Coll., *12*, 92	—	—— —
7	W.	1906	Min. Coll., *13*, 162	W	Thin coating B
8	Prof. A. P. Brown	——	Priv. Com.	U	Large mass A
9	W.	1907	——	W	Thin coating B
10	Dr. Charles Travis	1905	Priv. Com.	W	Thin coating B
11	T. D. Rand	(1892)	P.A.N.S., *1892*, 176	R	Small mass B
12	T. D. Rand	(1892)	P.A.N.S., *1892*, 194	R	Coating B
13	T. D. Rand	(1892)	P.A.N.S., *1892*, 193	—	—— —
14	(F. A. Genth)	(1874)	Min. Penna., 152	—	—— —
15	Mr. T. J. Lewis	——	Priv. Com.	W	Thin coating B
16	T. D. Rand	1878	P.A.N.S., *1878*, 408	R	Coating B
17	Mr. H. Miller	1907	Priv. Com.	W	Cryst. scales B
18	D Charles Travis	1905	Priv. Com.	W	Cryst. scales B
19	Mr E. A. Groth	(1902)	Min. Coll., *9*, 169	—	—— —
20	(J. D. Dana)	(1854)	Syst. Min., *4*, 430	A	Cryst. scales B
21	Mr. E. S. Law	1905	Min. Coll., *12*, 92	—	—— —
22	T. D. Rand	——	——	R	Cryst. scales B
23	T. D. Rand	(1874)	Min. Penna., 144	U	" B
24	T. D. Rand	(1874)	Min. Penna., 144	R	" B
25	T. D. Rand	——	——	R	" B
26	(F. A. Genth)	(1874)	Min. Penna., 144	R	" C
27	Mr. W. H. Tomlinson	1901	Min. Coll., *8*, 144	W	" B
28	W.	1907	——	W	" B
29	Mr. S. MacFeeters	——	Priv. Com.	—	—— —
30	T. D. Rand	(1868)	Syst. Min., *5*, 780	R	Cryst. scales B
31	T. D. Rand	——	——	A	" B
32	E. D. Drown	1892	P.A.N.S., *1892*, 182	R	Traces D
33	T. D. Rand	——	——	U	Cryst. scales B
34	T. D. Rand	(1874)	Min. Penna., 144	U	" B
35	T. D Rand	——	——	R	" C

No.	Species	Principal Constituents	Minor Constituents	Locality
36	Columbite	Cb, Ta, Fe, Mn.	U.?	Broad & Olney
37	"	"	"	Morton
38	"	"	"	Avondale B
39	"	"	"	Mineral Hill A
40	"	"	"	Black Horse
41	"	"	"	A. Smedley's
42	"	"	"	Boothwyn
43	"	"	"	Landenberg
44	Euxenite	Cb, Ta, Ti, Y, U.	——	Morton
45	"	"	——	Delaware Co.
46	Fergusonite?	Cb, Ta, Y, Ce, U.	——	A. Smedley's
47	Microlite?	Cb, Ta, Ca, U.	——	Mineral Hill A
48	Samarskite?	Cb, Ta, Ce, Y, U.	——	Mineral Hill B
49	Allanite	Ce, Ca, Al, Fe, Si.	Th.	Mount Airy
50	"	"	"	Rittenhouse
51	"	"	"	Frankford B
52	"	"	"	Morton
53	"	"	"	Lenni
54	"	"	"	E. Bradford A
55	"	"	"	Pughtown
56	"	"	"	Bethlehem
57	"	"	"	Easton A
58	"	"	"	Lehigh Mt.
59	"	"	"	Pricetown
60	Monazite	Ce. P.	Th.	Morgan
61	"	"	"	Boothwyn
62	Zircon	Zr. Si.	Th.?	Neshaminy
63	"	"	"	Scottsville
64	"	"	"	Vanartsdalen's
65	"	"	"	Rocksville
66	"	"	"	Willow Grove
67	"	"	"	Dismal Run
68	"	"	"	Blue Hill
69	"	"	"	Brandywine S.

No.	Discovered By	Date	Reference	Source	Description	Intensity
36	W.	1904	Min. Coll., *14*, 42	W	Small xls	C
37	W.	1906	Min. Coll., *13*, 162	W	Grains	B
38	Mr. E. S. Law	1906	Min. Coll., *13*, 79	L	Crystal	C
39	(H. C. Lewis)	1882	P.A.N.S., *1882*, 51	R	"	D
40	J. T. M. Cardeza	(1892)	P.A.N.S., *1892*, 200	—	—	—
41	J. T. M. Cardeza	(1892)	P.A.N.S., *1892*, 200	—	—	—
42	J. T. M. Cardeza	—	—	R	Crystals	D
43	Samuel Tyson	1853	Min. Penna., 137	—	—	—
44	Mr. E. S. Law	1905	Min. Coll., *14*, 33	L	Crystals	B
45	Mr. John Eyerman	—	Priv. Com.	—	—	—
46	J. T. M. Cardeza	(1892)	P.A.N.S., *1892*, 200	—	—	—
47	W.	1907	—	W	Minute grains	B
48	W.	1907	—	W	"	B
49	W.	1907	—	W	"	?
50	Mr. S. H. Hamilton	—	Priv. Com.	—	—	—
51	W.	1906	Min. Coll., *13*, 63	W	Cryst. masses	D
52	W.	1906	Min. Coll., *13*, 173	W	"	C
53	Mr. H. C. Borden	—	Priv. Com.	—	—	—
54	W. W. Jefferis	(1850)	Syst. Min., *3*, 356	U	Lumps	D
55	(J. D. Dana)	(1892)	Syst. Min, *6*, 1067	—	—	—
56	(J. D Dana)	(1868)	Syst. Min., *5*, 289	A	Rough xls	D
57	(J. D. Dana)	(1868)	Syst. Min., *5*, 289	—	—	—
58	(F. A. Genth)	1874	Min. Penna., 80	—	—	—
59	(J. D. Dana)	(1868)	Syst. Min., *5*, 289	R	Lumps	?
60	Mr. J. G. Dailey	1899	P.A.N.S., *1899*, 377	R	Small xl	C
61	W.	1906	Min. Coll., *14*, 45	W	Crystals	B
62	Mr. J. F. Vanartsdalen	—	Priv. Com.	W	"	?
63	Mr. J. F. Vanartsdalen	—	Priv. Com.	—	—	—
64	Edward Swift	1829	J.A.N.S., *6*, (1) 48	R	Crystals	D
65	W.	1903	Min. Coll., *13*, 22	W	"	D
66	Isaac Lea	(1821)	J.A.N.S., *1*, (2) 470	—	—	—
67	(F. A. Genth)	(1874)	Min. Penna., 77	—	—	—
68	(F. A. Genth)	(1874)	Min. Penna., 77	—	—	—
69	(J. D. Dana)	(1850)	Syst. Min., *3*, 655	—	—	—

No.	Species	Principal Constituents	Minor Constituents	Locality
70	Zircon	Zr. Si.	Th. ?	E. Bradford B
71	"	"	"	Copesville
72	"	"	"	E Marlboro
73	"	"	"	Pughtown
74	"	"	"	Springton
75	"	"	"	Chester Springs
76	"	"	"	Coventryville
77	"	"	"	Easton B
78	"	"	"	Bethlehem
79	"	"	"	Hellertown
80	"	"	"	Pricetown
81	Cyrtolite ?	"	Ce, U, Th	Mermaid
82	"	"	"	Broad & Olney
83	"	"	"	Morton
84	"	"	"	Avondale A
85	"	"	"	Morgan
86	" brown	"	"	Boothwyn
87	" yellow	"	"	Boothwyn
88	Massicot ?	Pb.	U. ?	Morton
89	Uran-Hyalite	Si.	U.	Frankford A
90	"	Si.	U.	Fairmount A
91	Titanite	Ti, Si, Ca.	Th.	Canal Road
92	"	"	"	Morton
93	"	"	"	Chadd's Ford

ABBREVIATIONS.

Reference Column.

Priv. Com.—Private Communication.

A. J. S.—American Journal of Science, New Haven.

J. A. N. S.—Journal of the Academy of Natural Sciences of Philadelphia, 1st series.

Min. Coll.—Mineral Collector, New York.

Min. Penna.—A preliminary report on the mineralogy of Pennsylvania, by Frederick A. Genth; Report B, Second Geological Survey of Pennsylvania, Harrisburg, 1874-1875.

P. A. N. S.—Proceedings of the Academy of Natural Sciences of Philad'a.

Syst. Min.—A System of Mineralogy, by James D. Dana, six editions, New York, 1837, 1844, 1850, 1854, 1868, 1892.

No.	Discovered By	Date	Reference	Source	Description	Intensity
70	Isaac Lea	1818	J.A N.S., *1*, (2)470	—	——	—
71	(J. D. Dana)	1868	Syst. Min., *5*, 777	—	——	—
72	G. W. Carpenter	1826	A.J.S., (1) *10*, 221	A	Crystals	D
73	(J. D. Dana)	(1850)	Syst. Min., *3*, 654	—	——	—
74	Mr. F. J. Keeley	1905	Priv. Com.	—	——	—
75	(J. D. Dana)	(1850)	Syst. Min., *3*, 654	A	Crystals	?
76	(J. D. Dana)	(1850)	Syst. Min., *3*, 654	—	——	—
77	J. Finch	1824	A.J.S., (1) *8*, 239	—	——	—
78	(J. D. Dana)	(1868)	Syst. Min., *5*, 779	A	Crystals	?
79	(F. A. Genth)	(1874)	Min. Penna., 76	—	——	—
80	(J. D. Dana)	(1868)	Syst. Min., *5*, 275	A	Crystals	?
81	W.	1907	——	W	Rough xl	B
82	W.	1905	——	W	Minute xls	C
83	W.	1907	——	W	"	C
84	W.	1904	——	W	"	C
85	Mr. W. H. Tomlinson	1898	Min. Coll., *5*, 177	W	"	C
86	W.	1906	Min. Coll., *14*, 13	W	"	C
87	W.	1906	——	W	"	C
88	Mr. E. S. Law	1905	Min. Coll., *12*, 68	W	Minute grains	D
89	T. D. Rand	(1874)	Min. Penna., 61	R	Coating	D
90	T. D Rand	(1892)	P A.N.S., *1892*, 176	A	"	D
91	L. Vanuxem	1818	J.A.N.S., *1*, (2) 469	A	Crystals	D
92	W.	1906	Min. Coll., *13*, 155	W	"	D
93	G. W. Carpenter	1826	A.J S., (1) *10*, 220	R	"	D

ABBREVIATIONS—(Continued).

Source Column. The collections of:
A.—The Academy of Natural Sciences.
L.—Mr. E. Stanley Law.
R.—Theodore D. Rand (Bryn Mawr College).
U.—The University of Pennsylvania.
V.—Mr. George Vaux, Jr.
W.—The writer.

Character Column.
Xls.—Crystals.
Cryst.—Crystalline.

Intensity Column.
A.—Very strongly active: good print in five days.
B.—Moderately active; strong print in three weeks.
C.—Feebly active; fair print in three weeks.
D.—Faintly active; barely discernible print in three weeks.
?.—No print in three weeks.

81-87. *Cyrtolite.* A series of more or less tetragonal looking minerals, varying from yellow to black in color. Form a second order prism with first order pyramid, usually simulating a rhombic dodecahedron; faces often very unequally developed, and occasionally curved. Frequently surrounded by radiating cracks in the rock, identical with the "stars" described by Hidden,* but rarely more than a centimeter across. These "stars" are apparently to be regarded as natural radiographs, for they can only have been produced by the influence of the radiations emitted by the crystals in determining the direction of the cracks developing in the granular quartz matrix while in process of solidification. They are sometimes found around other active minerals, but never around inactive ones. A photograph of a specimen of cyrtolite, recently found at Morgan, Delaware County, by Mr. E. S. Law, is shown at Figure 2, plate 1.

88. *Massicot.* A greenish gray earthy material which gives before the blowpipe reactions for lead, but in which no other elements could be detected with certainty.

The following arrangement is adopted:

Uranium oxides
carbonates
phosphates
Columbates
Rare earth silicates
phosphates
Zirconium silicates
Miscellaneous.

The constituents given are of course understood to be present in the form of oxides. They represent only the usual composition of the respective minerals, for, with one or two exceptions, the material here used has never been analyzed.

The localities are necessarily stated only briefly in the table and in order to describe them more fully, a check list is appended. Their arrangement is geographical, rather than geological.

The original discoverer of each occurrence is given as far as practicable; in the cases where no such information is at hand,

*Some results of late mineral research in Llano County, Texas. Amer. Jour. Sci., (4), 19, 1905, 425-433.

the name of the person who first announced it is introduced, in parenthesis, instead. The same applies to the year in which the material was first found.

In the reference column is given the place where notice of each occurrence was first published. When no reference is stated, it is understood that the material is preserved in the collection of the discoverer, but has never been announced or described. A list of the abbreviations used in this column is added below.

The collections from which the specimens tried were obtained are indicated in the column headed source by letters explained in the list of abbreviations. The writer embraces this opportunity to thank those in charge of the various collections for permission to make use of specimens and for assistance in carrying out the experiments.

The intensity given is not to be regarded as exact, for the results are not directly comparable on account of the uncertainty introduced by the varying character of the specimens. At least four different degrees can, however, be distinctly recognized, and they are described by appropriate letters.

CHECK LIST OF LOCALITIES.

Philadelphia County.

NORTHWEST SECTION.

Mt. Airy: McCrea's Quarry, at corner of Mermaid and Germantown Avenues.

Gummite ?	Torbernite
Uranochre ?	Allanite ?
Autunite	

Mermaid: Comly's Quarry, one-eighth mile southeast of Mermaid Station, P. & R. Ry.

Torbernite	Cyrtolite ?

Wingohocking: Quarries east of Wingohocking Station, P. & R. Ry.
Torbernite

Rittenhouse: The Rittenhouse Quarry, on Rittenhouse Lane, west of Wissahickon Avenue.
Allanite ?

Broad and Olney: Exposures at southeast corner of Broad Street and Olney Avenue. (Now walled up.)

Uranochre ?	Columbite
Autunite	Cyrtolite ?

NORTHEAST SECTION.

Frankford A.: The Frankford Quarry, at Leiper and Church Streets. (Abandoned.)

Randite	Uran-Hyalite

Frankford B.: Hoffman's Quarry, Fisher's Lane and Tacony Creek.
Allanite (Scheelite)

WESTERN SECTION.

Canal Road: "Quarry at the end of the Canal Road on the Schuylkill River." (Inaccessible.)
Titanite

Girard Avenue: Exposures on West River Drive, north of Girard Avenue Bridge.
Autunite

Fairmount A.: Quarry on Schuylkill River, opposite Fairmount Water Works. (Inaccessible.)
Uraninite Torbernite
Uranochre ? Uran-Hyalite
Autunite

Fairmount B.: Excavations and quarries for Penna. R. R. yards, just west of Fairmount A.
Autunite Torbernite

Bucks County.

Neshaminy: Exposures on Neshaminy Creek one-half mile northeast of Neshaminy Falls Station, P. & R. Ry., Southampton Township.
Zircon

Scottsville: Roadside exposures northwest of Scottsville, Southampton Township.
Zircon

Vanartsdalens: Vanartsdalen's limestone quarry, two miles north of Neshaminy Falls Station, P. & R. Ry., Southampton Township.
Zircon

Rocksville: Finney's Quarry, on Mill Creek, east of Rocksville, Northampton Township.
Zircon

Montgomery County.

Jenkintown: Heacock's Quarry, in Wyncote, one-quarter mile west of Jenkintown Station, P. & R. Ry., Cheltenham Township. Abandoned.
Torbernite

Willow Grove: Exposures along Old York Road, above Willow Grove, Moreland Township.
Zircon

Delaware County.

Llanerch: Cut on P. & W. Ry., one mile northeast of Llanerch, Haverford Township.
Gummite Autunite

Morton: Johnson's Quarry, three-quarters mile northwest of Morton Station, P., B. & W. R. R., Springfield Township.
Columbite Cyrtolite ?
Euxenite Massicot ?
Allanite Titanite

Swarthmore: Exposures along Crum Creek, one-half mile northwest of Swarthmore, Springfield Township.
Uraninite Gummite

Avondale A.: Leiper's Quarry, on Crum Creek, at Avondale, Springfield Township.

Uraninite	Autunite
Gummite	Torbernite
Uranochre?	Cyrtolite ?

Avondale B.: Quarry on west side of Crum Creek, south of Avondale A., Ridley Township.

Columbite

Leiperville: Deshong's Quarries, on the B. & O. R. R., west of Leiperville, Ridley Township.

Uranochre ?	Torbernite
Autunite	

Chester: "Near Chester."

Uraninite	Autunite
Uranochre ?	Torbernite

Upland: Samuel Crozer's Quarry, south of Upland, Chester Township.

Autunite

Blue Hill: Exposures west of Blue Hill, Upper Providence Township.

Zircon

Dismal Run: Painter's farm, on Dismal Run, one mile north of Lima, Middletown Township.

Zircon

Mineral Hill A.: Exposures north of Crump's serpentine quarry, one mile west of Media, Middletown Township.

Columbite	Microlite ?

Mineral Hill B.: Exposures west of Crump's Quarry, Middletown Township.

Samarskite ?

Black Horse: John Smith's farm, one-half mile east of Black Horse, Middletown Township.

Columbite

A. Smedley's: "On A. Smedley's farm," Middletown Township.

Columbite	Fergusonite ?

Lenni: Quarry on P., B. & W. R. R., west of Lenni Station, Middletown Township.

Allanite

Morgan: Quarries and exposures on Chester Creek Branch P., B. & W. R. R., south of Morgan Station, Aston Township.

Monazite	Cyrtolite ?

Boothwyn: Quarry south of B. & O. R. R., one-half mile southwest of Boothwyn Station, Upper Chichester Township.

Columbite	Cyrtolite, brown, prismatic
Monazite	Cyrtolite, yellow, "dodecahedral"

Brandywine Summit: Bullock's Quarry, one mile southwest of Brandywine Summit, Birmingham Township.

Zircon

Chester County.

East Bradford A.: Amos Davis's farm, one mile southwest of West Chester, East Bradford Township.

Allanite

East Bradford B.: "Two miles west of West Chester."
Zircon

Copesville: "Exposures near the Paper Mill, on the Brandywine, one mile south of Copesville," East Bradford Township.
Zircon

Chadd's Ford: Quarry west of Brandywine Creek, two miles northwest of Chadd's Ford, Pennsbury Township.
Titanite

East Marlborough: "Near Pusey's Saw Mill," East Marlborough Township.
Zircon

Landenberg: Nevin's Quarry, southwest of Landenberg, London Britain Township.
Columbite

Springton: Exposures near Springton School House, Wallace Township.
Zircon

Chester Springs: In the iron mines near Chester Springs and Yellow Springs, West Pikeland Township.
Zircon

Coventryville: Christman's Quarry, one-half mile south of Coventryville, South Coventry Township.
Zircon

Pughtown: Exposures south of Pughtown, South Coventry Township.
Allanite Zircon

Northampton County.

Easton A.: In the South Mountain, west of Easton.
Allanite

Easton B.: Quarries on Chestnut Hill, north of Easton.
Zircon

Bethlehem: In the South Mountains, three-quarters mile from Bethlehem.
Allanite

Lehigh Mountain: "Just south of Lehigh University."
Allanite

Hellertown: "In the South Mountains, one mile east of Hellertown."
Zircon

Berks County.

Pricetown: At Eckhardt's Furnace, and on several farms near Pricetown, ten miles northeast of Reading.
Allanite Zircon

Carbon County.

Mauch Chunk.
Uranochre ? Autunite

Sections.

(Abstract of Proceedings of Stated Meetings.)

MECHANICAL AND ENGINEERING SECTION.—Stated meeting held Thursday, November 27, at 8 P.M. President Charles Day in the chair. Present 125 members and visitors.

The paper of the evening was read by Mr. Richard L. Humphrey, on "The Work of the Structural Materials Laboratories."

The paper is reserved for publication in the *Journal*.

FRANCIS HEAD, *Sec'y.*

ELECTRICAL SECTION.—Stated meeting held Thursday, December 5, 8 P.M. Mr. Thomas Spencer in the chair. Present, eighty-two members and visitors. Mr. Edward R. Taylor, of Penn Yan, N. Y., read the paper of the evening on "The Method and Apparatus for the Manufacture of Carbon Di-Sulphide by the Electro-thermic Process." The paper was fully discussed and was referred to the Committee on Publication. The speaker received a vote of thanks for his interesting communication.

RICHARD L. BINDER, *Sec'y.*

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—Stated meeting held Thursday, December 12, at 8 P.M. Dr. Wahl in the chair. Present, 149 members and visitors. Dr. ——— Baer presented an interesting account of the methods adopted and practiced for the production of moving pictures, and illustrated his theme by the exhibition of a number of characteristic moving pictures.

The thanks of the meeting were tendered to the speaker of the evening.

Adjourned.

M. I. WILBERT, *Sec'y.*

The Franklin Institute.

(Proceedings of the stated meeting held Wednesday, December 18th, 1907.)

HALL OF THE INSTITUTE,
Philadelphia, Dec. 18, 1907.

President WALTON CLARK in the chair.

Present 146 members and visitors.

Additions to membership since last report, five.

The following nominations for officers, managers and committeemen to be voted for at the Annual Election to be held on Wednesday, January 15, 1908, were made:

For President,	(to serve one year).....	WALTON CLARK.
" *Vice-President,*	(" three years).....	WASHINGTON JONES.
" *Treasurer,*	(" one year).....	CYRUS BORGNER.
" *Secretary,*	(" one year).....	WILLIAM H. WAHL.
" *Auditor,*	(" three years).....	WILLIAM H. GREENE.

For Managers (to serve three years).

James Christie,	Walton Forstall,	Isaac Norris, Jr.,
John Birkinbine,	Louis E. Levy,	Coleman Sellers, Jr.
Thomas P. Conard,	Richard Waln Meirs,	

(To serve two years.)
Chas. E. Ronaldson.

For the Committee on the Science and the Arts (to serve three years).

A. W. Allen,	Edward Goldsmith,	James S. Rogers,
Carl G. Barth,	Caspar Wistar Haines,	E. Alex. Scott,
Hugo Bilgram,	Clarence A. Hall,	Harrison Souder,
Frank P. Brown,	Lewis M. Haupt,	Martin I. Wilbert,
Kern Dodge,	Robert Job,	Richard Zeckwer,
W. C. L. Eglin,	G. H. Meeker,	Chas. J. Zentmayer.
J. Logan Fitts,	Lucien E. Picolet,	

(To serve two years.)
Eugene S. Powers.

The business of the evening was devoted to a series of informal communications on "Æriai Navigation." Mr. W. N. Jennings opened the subject by exhibiting a most interesting series of pictures taken during a number of balloon trips.

Dr. T. Chalmers Fulton, President of the Ben. Franklin Æronautical Society, followed with some remarks on the subject of "The Air: the Future Highway of Traffic and Transit."

Mr. Arthur T. Atherholt gave an interesting account of "A Balloon Trip from St. Louis to Canada."

This subject was closed by some highly interesting remarks by Prof. Samuel A. King, the veteran æronaut of Philadelphia, on "The Pleasures of Ballooning."

The President extended the thanks of the meeting to the speakers.

On Dr. Edward Goldsmith's motion, numerously seconded, the following preamble and resolutions were unanimously adopted:

"Whereas, The Franklin Institute has learned with much gratification of the contribution by Mrs. Anna Weightman Walker of Fifty Thousand Dollars to the Building Fund of the Institute; therefore

Resolved, That the grateful thanks of the Institute are due and are hereby tendered to the donor for this generous gift;

Resolved, That the gift be applied in some manner, which shall be acceptable to the donor, to establish, in connection with the new building of the Institute, a memorial of the late William Weightman."

Adjourned.

Wm. H. Wahl, *Secretary.*